JOURNAL OF MAMMALOGY

Published Quarterly by the American Society of Mammalogists

VOL. 41 20 MAY 1960 No. 2

GRAZING SUCCESSION AMONG EAST AFRICAN GAME ANIMALS

BY DESMOND FOSTER VESEY-FITZGERALD

The Rukwa valley in southwestern Tanganyika Territory is enclosed to the east and west by high escarpments. On the valley floor an extensive flood plain of open grassland surrounds a shallow saline lake, and the grassland itself is bordered by open woodlands of *Acacia* and other trees. The whole of the plain is a game-protected area, and it is occupied by a number of species of herbivorous mammals which together form an intact faunal unit. The area is therefore a very suitable one in which to study a resident and relatively undisturbed natural fauna. The Rukwa flood plain is also one of the outbreak areas of the red locust (*Nomadacris septemfasciata*); in connection with the control of this species the climate and ecology of the valley have been studied in some detail for a period of nearly ten years. There is, therefore, a considerable background of information available to observations on the wildlife.

The climate is characterized by a rainy season, extending from November to April, and the remaining months are dry. The rainfall averages 31 in. (79 cm.) and in addition the plains usually become flooded due to the overflow of the rivers which drain into the valley. Flood water may lie on the land for up to five months after the rains have ceased. The drainage is closed and so when the lake fills, extensive areas of the flat shorelands become flooded with brackish water. The rainfall is most irregular, however, and during years of low precipitation, flooding on the plains is very reduced and the evaporation from the lake surface exceeds replenishment. Under these circumstances the north lake may even dry up completely during the dry season, and there may be no surface water in the valley for several months at a time. The whole regime is therefore one of alternating flood and drought, for which reason the environment is very specialized.

THE PASTURE

An account of the grasslands in the Rukwa valley has been given by Vesey-FitzGerald (Anti-Locust Bull., 20: 1–30, 1955). The main formations present are as follows: The first series comprises the valley grassland associations which are conditioned by the drainage. Around the perimeter of the plains the characteristic grasses are *Hyparrhenia rufa*, *Chloris gayana* and *Sporobolus marginata*. Toward the center of the plain, where the precipitation is supplemented by flooding, the true flood plain grassland is established. This comprises an association of *Echinochloa pyramidalis* with *Cynodon dactylon*, or with

Cyperus edulis and *Scirpus maritimus*. In depressions and along water courses, where flooding is liable to be deeper and of more prolonged duration, *Vossia cuspidata* is the predominant grass, and this is often associated with *Oryza barthii*. The second series comprises the alkaline lake shore grasslands, of which there are three main types, namely, the grassland dominated by *Sporobolus robustus*, that where *Diplachne fusca* or *Cyperus leavigatus* are dominant, and that which extends over large areas when the lake is dry, the co-dominant species being *Sporobolus spicatus* and *Diplachne jeageri*. Within the zone of the lake shore grasslands, where the rivers spread out toward the lake, the delta grassland occurs. Here the dominant species is *Cynodon dactylon*, associated with *Paspalidium geminatum*. During seasons of extensive flooding much of this area is colonized by bullrushes, *Typha sp*. The third series of grasses are the woodland species, among which *Panicum maximum* and *Digitaria* sp. are prominent. These form a dense ground cover during the rains under the open canopy of the escarpment foot woodlands, especially on partially cleared cultivated lands, The fourth series are the *Acacia* parkland grasses, where *Cyperus usitatus* is the most important species and *Sporobolus marginatus* and *Echinochloa colonon* are common grasses. The flood plain and woodland grasses are mostly tall species (2–3 m.) while the lake shore and delta and parkland grasses are mainly rather short.

Most of the grasses mentioned, except those in the *Acacia* parkland, are perennials. All grow vigorously during the rains and flower when they reach maturity. After flowering, their growth period is at an end and then the perennials commence to dry off and conserve nutrients in their subterranean parts even if the ground is still moist. In this respect *Vossia* is exceptional because it does not flower unless a certain depth of flooding is maintained, but remains green longer into the dry season. Some of the tall perennials appear to be "sour", i.e., they do not provide favored grazing when they are mature or dry. *Vossia*, however, appears to be a "sweet" grass during any period of its growth. The shorter perennial and annual grasses also appear to be "sweet", i.e., they provide favored grazing even when mature and, in the case of the annuals, also when they are dry. Dry season grass fires, except when controlled, are practically universal through the area. After a fire has passed many of the perennial grasses come up green from their stools without the incidence of rain, and this regrowth provides a very favored though somewhat thin pasture during the dry months. The annual species, on the other hand, do not come up again until after the first showers.

THE FAUNA

Eighteen species of herbivorous animals are found in the Rukwa valley, and the grazing habits of the eight commonest, which spend all or a large part of their time on the open plains, are considered in some detail in the present paper. It will be convenient first to record briefly the grazing calendar of each of these more important species. Elephants, *Loxodonta africana*, spend the rains (January to April) mainly in the *Acacia* parkland and then among the long grass of the escarpment foot woodland. During this period they feed on grass and the foliage and fruits of trees, breaking off branches and knocking many trees over in the process. Small and scattered gardens are cultivated in the woods and toward the harvest season (March onwards) frequent complaints of damage by elephants are made. After the rains are over and the country begins to dry up (April to May) the elephants move to the drying water courses which are choked with *Vossia*, or to the banks of rivers where long grasses (*Echinochloa* and *Panicum*) and reeds (*Phragmites*) form dense stands. Trees (*Acacia*) and palm fruits (*Hyphaene* and *Borassus*) still provide much of their food. Water is still plentiful in pools. As the dry season advances (May to September) the elephants move out onto the flood plain where they feed on long grasses (*Echinochloa*) or consume the sweet canes of *Vossia* and the foliage of a shrub, *Aeschynomone*, in the more swampy depressions. Surface water is still plentiful at this time. Toward the end of the dry season (October to November) all surface water may dry up on the plains and the day temperatures increase. The elephants now leave the plains,

especially if the grasses have been burnt, and return to the shade of the woods. Water is likely to have a controlling influence on their movements at this season. Considerable distances may be traveled in order to visit water, but elephants will dig their own water holes in the sandy beds of dry rivers. Food may be less plentiful at this season and during these months the bark of certain trees (*Adansonia, Scleriocarya* and others) may be torn off by elephants. When drought conditions are not extreme, the herds may linger on among green fringes around lakes or along rivers, and in this manner tide themselves over the short period which remains before the rains commence.

The calendar of the buffalo, *Syncerus caffer*, is similar. The herds are found in the *Acacia* parkland and in the woods during the early part of the rains (January), where they feed on the vigorously growing grasses. They may linger on in this environment, but usually the main herds move to the lake shore and delta grasslands during February and March if these areas are not too flooded. After the rains have stopped, by which time the lake shore has usually become flooded, the buffalo start working the *Vossia* choked water courses in the woods. As the dry season advances they follow the elephants out on to the plains toward the rich *Vossia* pastures in depressions. If there have been grass fires on the plains and *Echinochloa* has started regrowth, the buffalo linger on these fresh pastures. Up to this time surface water will have been available throughout the area, but toward the end of the dry season it may become scarce or even completely lacking on the plains. Although buffalo will regularly visit water holes when available, the herds can remain for an indefinite period on the green pastures which become available in the dry season due to regrowth of *Echinochloa* after fire, or on the trampled *Vossia* meadows, without drinking. During the hot days of October and November, however, they may seek shade at noon. During recent years, the buffalo herds have spent more and more time on the open plains, possibly due to the complete protection from shooting which has been afforded them. As soon as the first showers fall in November, the annual grasses and bulbils of *Cyperus usitatus* sprout green in the *Acacia* parkland, and the buffalo then move onto this fresh pasture where they remain till the terrain becomes too flooded.

The hippopotamus, *Hippopotamus amphibius*, is more sendentary since its life is centered on the water in which it spends the day. A herd of about 400 animals was resident throughout the period of the present study in the Rungwa river which traverses the open plains. During the rains the hippopotami wander extensively and may turn up in quite unusual places. All these grasslands at this season provide a very suitable habitat for these animals. Naturally they follow the drainage channels, but on the lake shore plains their routes across the soft mud become gouged out in narrow steep side trenches. These form connections between the different rivers and materially influence the drainage and therefore the distribution of the herbage in this zone. During the dry season the herd becomes restricted to the main river where the animals spend the day in favorite pools and graze at night on the river fringe and delta grassland. The dry flood plain grassland is not frequented at this season, but pregnant females retire to quiet reaches of the river passing through this zone, there to give birth to their single young in a secluded nursery. As the dry season proceeds the animals graze down the *Vossia* fringe of the water courses completely and later resort to the dry flood plain grasses if they have not been burnt. They eat considerable dry herbage as long as they still have access to water. In normal years some water remains in the river, but during drought years this dries up, as does the shallow lake. When the last of the water dries the animals wallow as best they can in the remaining mud. Under these circumstances some (but not all) animals wander a considerable distance in search of a more salubrious spot, but in really dry years there is virtually no place where surface water remains. The hippopotami suffer severely under these circumstances, because they are deprived not only of food and water, but also of shade. Nevertheless, they survive for many weeks, apparently living on their own fat, but gradually becoming very emaciated. During the severe drought of 1954, about 25 per cent of the herd perished. Several deaths took place in a little pool fed by a spring under the eastern escarpment, so

it appears that in these cases death was ultimately caused by starvation rather than lack of water. Thin green pasture existed throughout the season over the flood plain where the herbage had been burnt or trampled, but it appears that this was too meager to support so large an animal as the hippopotamus, although it sufficed for smaller animals. In any case the hippopotami made little or no attempt to use it. However, with the first showers and the growth of new grass, the surviving hippopotami spread out over the fresh pasture. The short but close growth of *Cyperus usitatus* in the *Acacia* parkland was particularly favored at this period, showing that hipppopotami can use a short pasture quite satisfactorily. The creatures are regular breeders and, despite the mortality during two consecutive drought years (1954–55), the herd had returned to its former strength by 1957.

Puku, *Adenotus vardoni*, are found at the northern limit of their range in the Rukwa valley and in several ways their habitat here is atypical. They are restricted to the delta grassland and that part of the flood plain grassland immediately adjacent to the meandering rivers. They share the pasture with the hippopotami—an association apparently not entirely fortuitous. During the rains they remain on the delta grasslands and adjacent areas of lake shore grassland. The delta grassland provides them with green grazing long into the dry season, and even when the grasses eventually wither the puku remain on this pasture provided water is available in the river. A particularly favored pasture in the dry season is provided by the perennial herbage (*Echinochloa* and *Vossia*) fringing the main river channel and the subsidiary trenches, which has been trampled down by hippopotami and subsequently come up green from ground level without the incidence of rain. During seasons of severe drought the channels of the delta dry out completely and the herbage withers and may be burnt. In these circumstances the puku follow the river upstream into the flood plain where they obtain forage from the perennial grasses which have been burnt or trampled by heavy animals. However, the puku still remain close to the river, and their association with the hippopotami continues because in drought years the last available surface water is in hippo-wallows and footprint puddles. Nevertheless, puku have been found to survive for at least several weeks without access to surface water, so long as they can graze on green (burnt) pasture. Even when the river is completely dry they do not desert it. The attraction of the dry water course at such times appears to be the shade under its steep banks during the heat of the day. In Rukwa there are no trees at all in the habitat occupied by the puku, so this availability of shade, even when no water remains in the river, seems to be important. As soon as the first showers fall the puku return to the delta grassland.

The most abundant antelope in the Rukwa valley is the topi, *Damaliscalus korrigum*, which here occupies the southern limit of its range in this part of Africa. This species is the characteristic animal of the perimeter, flood plain and lakeshore grasslands. In December, at the beginning of the rains, the main herds are on the fresh green pasture of *Cyperus usitatus* in the *Acacia* parkland, and on the perimeter grasslands which are coming up green after the first showers. The *Acacia* parkland soon becomes water-logged and the topi herds all move onto the perimeter grasslands, but they will return to the parkland if dry conditions prevail. A vast concentration assembles on favored places which remain dry and the rut takes place from February to April (Vesey-FitzGerald, Oryx, 3: 1–4, 1955). During these months the grasses in the valley are long and much of the area is flooded. However, the great concentration of animals on the dry ground over a limited area keeps the herbage short and actively growing. Here animals remain until conditions become drier elsewhere. After the rains have ceased the herds move on to the lakeshore and delta grasslands as these dry out, and disperse over the perimeter grasslands where early fires have occurred. The males tend to wander off by themselves at this season and may be found alone throughout the flood plain grassland and in the *Acacia* parkland. During the first half of the dry season there is a marked tendency for the topi to follow the fires. They may be seen on burnt ground so soon after the fire as to indicate that some salt content in the ash attracts them. Within a day or two, however, colonies of *Imperata cylindrica* produce

green shoots which provide a favored food. Within a week, other species of perennial grasses are coming up green, and these provide a valued pasture for the topi. Although surface water is normally available in many places during the first half of the dry season, the topi do not leave green pastures to seek a drink. Later in the year, surface water becomes limited to one or two water holes, but topi never frequent them. As the dry season advances the main herd concentrates on the *Vossia* pasture which has by this time been trampled by heavy animals such as elephant and buffalo. The *Vossia* pasture has the appearance of a short-grass meadow because the wet-season growth has been trampled flat and dry-season shoots are growing vigorously from ground level. The *Echinochloa* areas, after the dry straw has been burnt off, appear similar and are much appreciated by the topi. The animals remain on this pasture throughout the dry season, but seek shade in the tree line during the heat of the day. During September and October the lambs are born and, as soon as the first showers fall in November, the breeding herds move toward the perimeter grasslands and to the highly favored pasture of *Cyperus usitatus* in the *Acacia* parkland where they remain until the ground becomes too waterlogged.

The zebras, *Equus burchelli*, are close associates of the topi. Early in the rains (January) they concentrate on the *Cyperus usitatus* pasture in the *Acacia* parkland. There is much neighing at this season, suggesting that the stallions are sexually active. However, zebra do not appear to drop their foals at any particular season. When the parkland becomes waterlogged, some follow the topi to the short-grass area of the perimeter grasslands where they remain together until the movement to the delta grassland takes place. Zebra favor the lakeshore sward of *Sporobolus spicatus* more than the topi, and remain on this pasture as long as they have access to drinking water in the river. During the early months of the dry season, zebra graze on dry annual grasses in the *Acacia* parkland, if these have not already been burnt off and if surface water is still available. As the season advances the zebra herds tend to remain near such water as may persist, but as these pools dry up the animals move into the flood plain wherever the dry grass has been burnt and green growth from perennial stools of *Echinochloa, Imperator* and possibly *Cynodon* has come up. With this fresh pasture available, it is not essential for them to drink but they frequent water as long as possible. By September the zebra are joining the great movement of topi toward the *Vossia* pasture, already trampled by elephant and buffalo. Soon after the first showers, the big concentrations of animals on the *Vossia* pasture break up and the zebra move off with the topi to the fresh *Cyperus usitatus* in the *Acacia* parkland.

The bohor reedbuck, *Redunca redunca*, is the second most abundant antelope on the Rukwa plains. There may be no other area in Africa at present where this species is so numerous. The species here reaches the southern limit of its range in this part of Africa, nor has it been recorded over the border in Northern Rhodesia. The southern reedbuck, *R. arundinum*, does not occur in the Rukwa valley at all. The bohor is confined to the flood plain *Echinochloa-Cynodon-Cyperus* association. It is usually not gregarious, but may be seen in small family parties consisting of a buck, doe and single young, or of a doe and young with the bucks remaining by themselves. They graze on the short grass lawns and shelter in the long grass stands. The bohor never frequents the *Acacia* parkland, is less common in the perimeter grasslands, and is seldom seen on the delta or lakeshore pastures. They frequent the channels on the flood plain where *Vossia* and *Oryza* seem to be favored. With the advance of the dry season, burnt ground with new growths of perennial grasses provides them with an attractive pasture. Green patches of *Imperator* are particularly favored, especially where isolated trees afford shade. Burnt firebreaks are also attractive with pasture and shelter adjacent. In such places concentrations of bohor may be seen but, when disturbed, they scatter in all directions, showing that they do not form a true flock but rather concentrate for common pasturage. Bohor do not drink when green herbage is available. At the end of the dry season, during drought years, they join the concentration of other animals on the trampled *Vossia* pasture, but spread

out over the flood plain grassland as soon as the first showers fall instead of following the other game to the fresh annual grasses.

The eland, *Taurotragus oryx*, is not so abundant in the Rukwa valley as the animals previously mentioned. However, herds of 60 to 80 are not infrequently encountered, and these are probably larger than the average seen in Africa at the present time. Eland are close associates of zebra and topi, and their grazing calendar is similar. During the rains they graze with the topi on the dry perimeter plains where the concentration of animals keeps the herbage short. During the early months of the dry season they are found on the short delta grasslands or on burnt ground. At the end of the dry season they join the concentration of animals on the *Vossia* pasture which has been trampled down by elephant and buffalo. They do not drink when green grass and shade are available. After the first showers they move to the green sward of annual grasses in the *Acacia* parkland.

Certain other species of animals which do not cooperate in the seasonal grazing program outlined above may be briefly mentioned. The giraffe, *Giraffa camelopardalis tippelskirchi*, is confined to the *Acacia* parkland and never enters the other grasslands. During the rains, when the parkland becomes waterlogged, the giraffe probably retire to the woods on slightly raised and more sandy soils. During the dry season they maintain themselves on the green foliage of *Acacia* and other species. These trees presumably tap deep ground moisture because they remain in leaf throughout the dry season, even though the ground herbage of annual grasses is quite dry. There is no evidence that the giraffe need to drink so long as green browsing and shade are available.

Impala, *Aepyceros melampus*, which are not abundant, are also confined to the *Acacia* parkland and a few places in the perimeter woods. They never venture into the flood plain. Impala are also browsers and the green foliage of herbs and bushes remains available to them during the dry season. These antelope are probably limited in their distribution by the availability of dry "islands" of sandy soil during the rains. During the dry season they frequent water holes, when available, and they use excavations made by elephants in sandy water courses. Toward the end of the dry season, in drought years, impala appear to move away from the *Acacia* park but this migration has not been followed. Soon after the first showers they return, accompanied by young lambs.

The wart hog, *Phocochoerus aethiopicus*, is also confined to the *Acacia* parkland and certain parts of the perimeter woods. Its distribution may be conditioned by the availability of aardvark (*Orycteropus*) holes in which to shelter. When water is available, these creatures like to wallow and presumably to drink. During the dry season, however, there may be absolutely no surface water in their habitat but they do not appear to suffer. Wart hogs maintain themselves during the dry season, when the herbage is withered or burnt, by rooting for rhizomes of perennial grasses and for the bulbils of *Cyperus usitatus*.

The roan antelope, *Hippotragus equinus*, and Lichtenstein's hartebeest, *Alcelaphus lichtensteini*, both occur in the area but are always scarce on the Rukwa plains, although quite common on other similar grasslands in the vicinity. No reason for this can be suggested, but it may be that they are less able to disperse with drinking water than are the other animals mentioned. Waterbuck, *Kobus defassa*, are local in the woodland fringe of the Rungwa river and graze on the edge of the adjacent flood plain grassland where green shoots are growing on burnt ground during the dry season. The common duiker, *Sylvicapra grimmia*, the bushbuck, *Tragelaphus scriptus*, and the steinbok, *Raphicerus campestris*, are all frequent in the perimeter woodlands but are not seen on the open plains from which they are apparently excluded by habitat preferences.

USE OF THE ENVIRONMENT BY THE ANIMALS

In the foregoing account of the habitat and its occupants the importance of flood and drought has been emphasized. These extreme conditions impose two critical periods on the fauna. Except for the hippopotamus, which revels in flooded conditions, the other animals are forced to take evasive action during the rains. Some retire to the drier perimeter of

the plains and some to raised areas in the parkland and woods, while the bohor reedbuck and puku, which remain on the flood plain, presumably resort to areas of shallower flooding. Due to these local seasonal movements of the animals, the different pastures benefit by periods of rest and it is interesting to observe how this natural balance operates between the herbivores and the grasses. Times of drought appear to impose more severe conditions on the fauna. But the fact that the perennial flood plain grasses shoot up green after trampling or burning, without the incidence of rain, insures that an ample pasture is available during the dry season. The plains animals become divided into two categories at this season, namely, the shaders and the drinkers, but this division is not rigid. The bohor reedbuck, topi and eland appear to be shaders by preference, while the zebra, buffalo, puku, hippopotamus and, of course, the elephant are essentially drinkers. During the dry season the former tend to frequent the green (burnt) pasture in the vicinity of the trees where they have no access to surface water, while the latter frequent the riverine pastures on the open plains without available shade. As a consequence of this restriction to the vicinity of shade or water, vast areas of the flood plain which are remote from either remain unoccupied, even though green grass may have come up there after fire. This fact may create the impression that the area is not adequately stocked, but it is clear from the grazing effect that this is not the case relative to suitable pasturage. In the driest years, when no surface water is available, and during the hottest months, when there is scarcely any dew at night, the animals assemble in the densest concentrations on the *Vossia* and *Echinochloa* pastures. The effect of the excessive grazing and trampling is to maintain these perennial grasses in the favored places in a short and actively growing condition. In this state the pasture resembles the sweet flush of the early rains, and with this feed the animals are able to maintain themselves without drinking. This phenomenon is well known to the desert Arab who has a special word for it, *jezzin*, "which is said of the great cattle in spring time when abstaining from water" (C. M. Doughty: Arabia Deserta; Jonathan Cape Ltd., 3d ed., 1926).

Consideration must now be given to the effect of the animals on the pasture. It has been shown in the foregoing account that the grazing and trampling of heavy animals in the *Vossia* swamp paves the way for the utilization of this valuable pasture by lighter animals. Similarly, the great concentration of animals, topi, accompanied by zebra, eland and buffalo, keeps the grass short and actively growing on the drier perimeter plains during the rains. Nevertheless, these favored pastures do not usually show any evidence of overgrazing, because it seems that a balance between stocking and grazing is continually maintained, owing to the exigencies of the season continually causing the animals to move from one area to the other. The richest pasture is the semi-permanent freshwater swamp area where *Vossia* is the dominant grass. But this area becomes flooded early in the rains and remains flooded longest into the dry season. During this period of flooding the grass grows robustly and although *Vossia* only flowers if the flood water reaches a sufficient depth, vegetative reproduction is always vigorous. There is, therefore, a period of at least eight months during which this pasture is rested from grazing by any animals except hippopotami. The most extensive pasture in the valley is the flood plain grassland where *Echinochloa pyramidalis* is the dominant grass. This area may become waterlogged early in the rains and often extensively flooded by February. In any case, it grows vigorously as soon as the rains start, and flowers and seeds before the end of the rains. During all this time the area is hardly occupied by any animals except bohor reedbuck, so the pasture is rested for at least five months of the growing period. After seeding, the grass dries off, but previously nutrients are stored in the rhizomes. In the dry state this herbage is not attractive to animals, although locally they may trample it down and graze on stool shoots at ground level as they do on the *Vossia* pasture. More often, however, fires sweep through this dry herbage from June onwards, and immediately regrowth from ground level takes place without the incidence of rain. Evidently this dry-season growth initiates from

the reserves stored in the rhizomes, and it provides a very favored pasture, during the four late dry-season months when green herbage is at a premium.

The perimeter grasslands, where *Chloris gayana* and *Hyparrhenia rufa* are abundant grasses, grow up vigorously during the rains, but certain parts of them are so heavily occupied at this time that the composition of the herbage is materially affected. This is, however, only a local effect due to the great concentration of animals which assembles when the adjacent grasslands become flooded. In general, the dry-season condition of the perimeter grasslands would by itself not be sufficiently lush to support a large enough fauna to damage the pasture during the growing period in the rains.

The pasture of annual grasses in the *Acacia* parkland is used at the beginning of the rains when growth of seedlings is most vigorous and so most able to withstand the grazing pressure imposed upon it. Before this pasture matures the animals move to drier ground so the herbage sets seed and dries off without being damaged by overstocking. The dry herbage retains some "sweetness" and is used by the animals immediately after the rains while pools of standing water remain. But this period of grazing does no harm to the herbage because its life cycle is completed and dry-season fires or the drying up of the pools cause the animals to vacate the area after a few weeks.

The lake shore grasslands, dominated by *Diplachne fusca,* become established under conditions of flooding by brackish water. This species vegetates and flowers during the late rains when the ground is waterlogged. During neither period is the ground occupied by herbivorous animals except hippopotami. When the ground becomes dry, the *Diplachne* grass dries off and, in this state, it is apparently not an attractive pasture. If the dry herbage is burnt, however, some regrowth occurs without the incidence of rain, and then the pasture is used to some extent by the animals but the *Vossia* and *Echinochloa* pastures appear always to be preferred. Thus there is never any grazing pressure on the *Diplachne* grassland. The *Sporobolus spicatus* pasture grows vigorously during dry periods because its habit is to colonize the salty lake-bed flats as the water recedes during drought years. Under such conditions green pasture is often at a premium and so the *Sporobolus* provides a convenient food, especially for zebra. However, because of the erratic circumstances under which *S. spicatus* colonizes new ground, there is little likelihood of overgrazing occurring in the case of this pasture.

ESTIMATION OF THE POPULATION

A game census on many estates in Britain has become an established criterion for gauging the season's sport. The success of closed seasons and other forms of legislation designed to protect wild animals is judged by periodic censuses. In Africa, despite the great interest and economic value of the fauna, practically nothing is known of the game populations which existed in the past, still exist, or could exist in any area. Yet successful conservation must be based on such data. On the open plains of the Rukwa valley, in respect of some of the commoner herbivorous animals, several methods of estimating the

TABLE 1.—*Census of some animals on N. Rukwa plains (c. 300 sq. mi.) during dry-season concentration, 1953 (all species have increased in recent years)*

SPECIES	DISPERSED POPULATION		MAIN HERD	TOTAL
	Density 1 sq. m.	Estimated total		
Topi	2.6	780	1500	2280
Zebra	1.4	420	177	597
Bohor reedbuck	3.0	900	—	900
Puku	—	—	218	218
Hippopotamus	—	—	c.400	400

populations have been tried. The first was a count of all animals encountered within 440 yards on either side of random traverses across the open north Rukwa plains during the dry season, when the grass had been burnt. This gave a figure for the population on one square mile for every two linear miles traversed and, by relating the figures obtained to ecological features such as water, green pasture, or shade, useful comparative results on the distribution of the animals were obtained. Also by comparing the figure obtained year by year, information was obtained about the stock present and the trend of its increase. It was not, however, possible to obtain a satisfactory figure for the total population of the valley by this method, because the boundaries of the area occupied by any particular species could not be sharply defined, and because the distribution of many of the species was extremely clumpy and, when really big herds were encountered, it proved impossible to decide how many animals were actually within the sample belt; also it was difficult to count the closely packed animals. However, as the work proceeded and information on the ecological distribution of each species was gained, it became possible to name certain species, namely topi, zebra, bohor reedbuck, puku and hippopotami, which were resident within a defined area, and to eliminate others such as elephant, buffalo and eland which certainly moved out of the area at certain times. In the former category, hippopotami and puku were confined within very narrow ecological limits during the dry season and so a total count of these two species was feasible. Bohor reedbuck were the most evenly distributed but, as they normally shelter in long grass during the day, a sample count of this species was not feasible over the whole area. The topi and zebra populations were fairly easily divided into those animals which were dispersed as singletons or in small groups, and those which were concentrated into one or two main herds. It was therefore possible to estimate the population of these two species by making a sample count of the dispersed animals, from which the average distribution per square mile could be deduced, and then to add to this figure total counts of the individuals composing the main herds, the location of which it was usually fairly easy to ascertain.

Applying such methods, a reasonably accurate estimate of the wildlife population of the North Rukwa plains has been made. This is summarized in Table 1.

A total count of topi and zebra and a rough estimate of the elephant and eland present on the central Rukwa plains was made during January 1958, the period of greatest wet-season concentration. This census was made in two stages. First, a reconnaissance flight was made over the area to locate the concentrations and confirm that no major herds were occupying other parts. A photographic record of all the herds of topi and zebra was then made from a height of 500–800 feet. Immediately afterwards (the same afternoon) all the areas of concentration were visited by Land Rover and a ground count of all ainmals present was made. The results of the photographic record and the ground count are summarized in Table 2.

The flight was routed with the object of including all the topi herds in the photographic cover, but even so three large herds, totaling about 600 animals, were seen but not photographed; these have been added to the total number counted on the prints. The zebra figure, on the other hand, includes mainly those animals actually photographed as it was

TABLE 2.—*Census of some animals on Central Rukwa plains (c. 500 sq. mi.) during wet-season concentration, 1958*

SPECIES	Aerial photograph	Ground visual.
Topi	3392	2730
Zebra	478	560
Eland	25	66
Elephant	105	9

not usually possible to count the number of zebra in distant scattered groups at the same time as the topi. One herd of eland, numbering three dozen animals, was evidently overlooked during the flight. In the case of the elephant, it was easy to see these large animals at a considerable distance from the air, but only nine were actually passed and seen during the land traverse. The ground count of topi is a minimum figure since some animals, especially young ones, were certainly obscured from a ground view in the more closely packed groups. With these reservations, it can be said with assurance that the resident population of topi on the central Rukwa plains is at the present time (1958) rather over 3000, and of zebra at least 600 (during a ground count in 1954, over 700 were seen). The eland live in a few big family herds, or as small groups of bulls, which are probably not entirely resident within the area. During February 1955, for example, three herds numbering 13, 84 and 70 were counted. No satisfactory count of the other animals present on the central Rukwa plains has been made.

Unfortunately, data on the vital statistics of wild animals in Africa are almost completely lacking. In the case of the topi and zebra, a difficulty arises at the start because it is not easy to differentiate the sexes of these animals from a distance. However, in the case of the topi, some tentative conclusions have been reached as a result of the periodic counts. It seems likely that the sex ratio is approximately 1:1. Only one lamb is born at a time; twins are evidently most unusual, indeed no certain case has been recorded. The gestation period approximates 9 months or rather less, and there is a very well-marked lambing season (September to October) once a year. The animals become full grown and indistinguishable from mature animals after about 12 months and it is likely that the females breed during their second year. Although there are asbolutely no data on the longevity of the species, it is assumed that this is not normally in excess of 10 years under natural conditions. A population of 3000 topi on 1 January might, therefore, be composed of 1000 males, 1000 females, 600 lambs and 400 yearlings, but of these figures only the one for lambs can be verified to any extent. Numerous counts have indicated that about two of every three mature females have a lamb each year, and during the census in central Rukwa between 400 and 500 lambs were actually counted. The figure is necessarily vague and probably on the low side, due to the fact that these young animals were often obscured by long grass or hidden among the full-grown animals in the flock. There may, therefore, be an increment of 600 young per year, and to balance this, after allowing for an estimated 6 per cent annual increase in the population during recent years of complete protection, a mortality amounting to about 500 animals a year must be assumed at the present time. It is believed that poaching is not rife in the Rukwa valley and predators (lion, leopard and hunting dogs) are not abundant, and if such causes account for the wastage of 500 topi a year this is probably a maximum figure. The reason that a more spectacular increase has not taken place is probably due to the ecological limitations on the fauna, as explained previously.

MANAGEMENT OF WILDLIFE AND PASTURE

In the Rukwa valley, as explained above, the open grassland plains and the animals which inhabit them are restricted by the special topography of the rift valley. But the general conclusions drawn from the present study are applicable to other areas under a similar rainfall regime where the vegetation catena is typically woodland—wooded grassland—valley grassland, zoned in relation to the drainage lines—that is to say, throughout that part of central Africa where *Brachystegia* and other genera comprise the dominant type of woodland vegetation, and where open grassland occurs in the valleys. Wildlife conservation may most successfully be achieved in such areas by providing as many favorable habitats as possible during the critical months of the dry season, so that as much as possible of the restricted pasture available at that time can be utilized without exposing the herds to increased predation.

It is obvious, in the Rukwa valley, that an increase of surface water during the dry

season and of dry land during the wet season would benefit the fauna. But concentrations of animals at such seasons renders them vulnerable to attack from predators, including man. It is, perhaps, not generally realized how important actual space is for the safety of a population of large animals which are diurnal and do not inhabit hidden retreats. Nor has the importance of the intact herd and the temporary concentration of different species of animals within a limited area previously been sufficiently stressed in relation to the use of pasture and management of wildlife.

The present study has yielded some useful information on these aspects of wildlife management. It is often difficult and expensive to provide and maintain artificial water points for the use of game. In the Rukwa valley, subterranean water is so brackish that offering it to animals might do more harm than good. In areas where good water supplies are available, or can be readily made available, on the other hand, there are often demands, other than game conservation, on the use of the land. In any case, concentrating game around water may encourage poaching and also be detrimental to the pasture. In the Rukwa valley an alternative is to provide shade; indeed, the same applies elsewhere in central Africa where the vegetation catena ends with valley grassland and where fresh growth of perennial grasses occurs during the dry season. Valley grasslands in the drainage lines are bordered with wooded grassland where animals can find ample shade, but the largest dry-season concentrations of animals occur on the flood plains which are usually shadeless, except around the perimeter, and animals which spend the day there are in danger from hunters. Therefore, an alternative to providing waterholes is to provide shade in the remote parts of of the open plain. Isolated trees often exist in such places and anything that can be done to extend or increase such natural groves is certain to benefit the animals. The more scattered such groves are, the harder it will be to ambush the animals and the less will be the grazing pressure exerted on surrounding pasture. If the fauna has been reduced, judicious burning will assist in providing favorable pasture during the dry months. Poachers appreciate this point and frequently burn the grass as a preliminary to luring animals to their doom. The conservationist can play at the same game by burning areas where the animals can be most easily protected.

During the rains the herds tend to disperse. Water and green grass become available over a wide area and the animals are not only protected by the spaciousness of their territory, but by the fact that they are more difficult to encounter in it. This safeguard to their welfare becomes increasingly important as the animals become scarcer; this is the reason that so many species in central Africa have been reduced in numbers, but none has yet been exterminated. But under the special conditions of the Rukwa valley, and in the case of certain species (puku in riverine habitats, lechwe on seasonally inundated grasslands), high flood may cause wet-season concentrations of animals on the dry perimeter though ample grazing exists. These concentrations are particularly vulnerable to attack from hunters and so special protection should be afforded them at such times. It is noteworthy that, in Northern Rhodesia, animals such as puku and lechwe, which are liable to be restricted in range during the wet season, are among the first to be eliminated from areas which they formerly occupied.

SUMMARY

The herbivorous animals and pastures of an undisturbed natural community are described. The latter are classified into four main series, namely, the valley grasslands, the alkaline lake shore grasslands, the wooded grasslands and the annual grass associations in the *Acacia* parkland. The grazing calendar of the eight commonest animals (elephant, buffalo, hippopotamus, puku, topi, zebra, bohor reedbuck, and eland) is recorded. The value of the various pastures at different times of the year is noted and the special importance of the dry-season growth of perennial grasses after burning or trampling is emphasized. It has been observed that animals feeding on green pasture do not need to drink, even during the

hot season, provided they have access to shade. The effect which large herds or heavy animals have in keeping the pastures in a favorable state is noted, and the dependance of one grazing species on another is mentioned; some other species with rather different feeding habits do not usually cooperate fully in this grazing program.

The significance of the alternating seasons of flood and drought on both the herbage and the animals is stressed and the effects of the animals on the pastures, and of the seasons on both the herbage and the animals, are described. It is shown that the pastures are rested at certain seasons and that stocking is conditioned by such factors as the availability of water or shade, or by the extent of flooding, and not by the total area of the habitat.

A census of the animals present was attempted and the methods employed are described. The figures arrived at are summarized and, although the stock seems small in relation to the total area, it is thought to be balanced in relation to limits set by the alternating periods of flood and drought. The implications of these limiting factors are considered and suggestions are made as to how the carrying capacity of a similar area might be improved.

International Red Locust Control Service, Abercorn, Northern Rhodesia. Received 12 February 1959.

STATUS AND DISTRIBUTION OF SEA OTTERS IN ALASKA

By Calvin J. Lensink

The original distribution of sea otters, *Enhydra lutris*, included the coastal area of the North Pacific Ocean and Bering Sea from Kamchatka south to the Kurile Islands and Hokkaido Island, thence eastward to the Commander, Aleutian, and Pribilof Islands, and the north American coast from the Alaska Peninsula to southern California. The longest gap in this distribution was the open-water area of about 185 miles between the Near Islands and the Commander Islands. The return of the Bering expedition with 900 sea otter pelts in 1742 initiated a period of exploitation of the sea otter in the Aleutian Islands and along the Northwest Coast, which ended 170 years later with the extirpation of the sea otter throughout most of its former range.

The early Russian period (1742–1799), was one of intense competition among many merchants, which resulted in a rapid decline of otters throughout the Aleutian Islands. The establishment of the Russian-American Company and its possession of charters granting it the exclusive right to the American trade, in 1799, brought a measure of order to the exploitation and even resulted in certain conservation measures. Thus, during the second charter (1821–1842) harvest quotas were set for each district, attempts were made to harvest only males, and rules were established to prevent unnecessary disturbance of the sea otter (Hooper, 1897). However, on the mainland coast, competition from foreign vessels, primarily Boston traders, resulted in continued ungoverned exploitation and the virtual extermination of the sea otters there. Petroff (1884) reports that 260,790 otter skins were shipped from America by the Russians prior to 1867, but this figure does not include skins that were smuggled to avoid payment of royalties to the Czar, nor does it include an estimate of skins lost in scores of shipwrecks. In the 40 years between 1780 and 1820, British, French, Spanish and American traders probably obtained

more furs than the Russians obtained during their entire occupation of Alaska. Sturgis (c. 1805) lists American ships in the fur trade for the years 1799–1802. During these four years 47,800 sea otter skins were obtained. Howay (1933) quotes Roquefeuil (1843) as saying that the years 1804–1807 produced 59,364 sea otter skins and that the year 1805 alone produced 17,445 skins. According to Howay, the next five years produced 47,962 sea otter skins. Baranof, in a report to the Board of Governors of the Russian-American Company in 1803, estimated that the British and American vessels had obtained between 10,000 and 15,000 sea otter pelts annually for the previous ten years (Khlebnikoff, 1835).

Sea otters decreased rapidly in the face of this excessive exploitation and by 1825 the maritime fur trade of the Northwest Coast as an entity had ceased and other items were sought to supplement cargoes. The Russians, however, continued to obtain about 1,000–2,000 skins annually, mostly from Kodiak and westward to the Aleutian Islands, and in the last five years of their occupation of Alaska harvested 11,137 skins (Petroff, 1884). The total number of sea otters killed by hunters of all nationalities during the 126 years of Russian occupation of Alaska probably exceeded 800,000.

The purchase of Alaska by the United States opened a new era of exploitation, particularly in the Kodiak Archipelago, along the Alaska Peninsula, and in the Aleutian Islands. Conservation measures which assured the Russians a sustained yield of sea otter skins were abandoned. During the first four years after the transfer, Americans took 12,208 otters, or more than the Russians had taken in the preceding ten years. The tempo of the slaughter increased over the next two decades. From 1871–1880 at least 40,283 otters were killed, and from 1881–1890 an additional 47,842 otters are known to have reached the market (Petroff, 1884; Allen, 1942). The next decade showed the effect of the excessive kill, as only 6,143 animals were obtained by the Alaska Commercial Company which by then had nearly monopolized the Alaska fur trade. In 1910 the only two American vessels left in the sea otter trade obtained only 16 otters with a crew of 40 Aleut hunters. Two British Columbia vessels obtained 7 otters, and 11 others were killed or found dead on beaches for a season's total of only 34 animals (Marsh and Cobb, 1911). In 1911, after hunting was no longer profitable, sea otters were given protection by provisions of the Fur Seal Treaty. This protection was further extended in 1913 by the establishment of the Aleutian Islands National Wildlife Refuge.

It is impossible to say just how many sea otters survived when hunting was stopped, but calculations based on our present estimate of the population and its distribution suggest that the number of animals could not have been less than 500.

In the first 20 years following the ban on hunting, reported observations of sea otters were scanty, as might be expected considering the few remaining in remote areas. During the 1930's, reports of otters from widely scattered points became increasingly frequent, and in 1936, the Murie Aleutian Island Expedi-

tion accounted for nearly all population centers that we now know to exist. From these reports it seems probable that a nucleus of animals survived in each population center, and that widespread migration to form new colonies did not occur.

RECENT STUDIES

The following sections report population studies conducted by the U. S. Fish and Wildlife Service and Purdue University from 1954 to 1957. I have drawn freely from reports and correspondence in the Service files but most items from this source are not specifically cited, thus avoiding a long list of titles not easily accessible to the reader.

Present information on sea otter numbers and distribution is derived from several sources. In 1954 I surveyed portions of the Andreanof and the Delarof Islands by air from a Navy UF (Albatross) and, in July and August of 1956, I surveyed Amchitka Island habitats from headlands with a telescope. In addition, sample areas were examined repeatedly to determine the daily rhythm of activity and to determine the effect of storms on local distribution patterns. The 1957 surveys, the most extensive, employed both boat and aerial observations, and covered the area from Cook Inlet to the Islands of the Four Mountains in the eastern Aleutians, and Adak and part of Kanaga Island in the central Aleutians. Earlier surveys which provide comparative data were made by the Fish and Wildlife Service in the Kodiak Archipelago, the Shumagin Islands, the Sandman Reefs, and on Amchitka Island. Information on Amchitka Island is available also from reports of Bureau of Fisheries Wardens, stationed there between 1936 and 1940, and from an aerial survey conducted by Refuge Manager Frank L. Beals and Navy Pilot G. T. Joynt in 1943. In addition to the various survey reports, a record of miscellaneous observations has been maintained in the Fish and Wildlife Service office at Juneau.

Although our survey information is incomplete, when it is supplemented with the many scattered observations it provides a reasonable basis for estimating the size of the population and for analysis of its status and distribution. This information indicates that there are at least 25,000 sea otters in Alaska and probably not more than 50,000. Until further data are obtained, the conservative figure is favored. The sea otters are found in several distinct population centers which are discussed by regions below.

POPULATION DISTRIBUTION AND STATUS

Southeastern Alaska.—Three unverified reports of sea otters are available from southeastern Alaska, the earliest in 1946 and the latest in January 1958. It is possible that these reports are valid and that there is a small population on the west side of Prince of Wales Island. In view of the scanty information, however, I am not able to state that there are sea otters in this area.

Cape St. Elias to Kenai Peninsula.—Prince William Sound, in the center of this area, has long been known to support an important sea otter population. This area has not been surveyed but many reliable observations of sea otters have been reported. These reports include a group of 50 at the southern ends of Latouche and Elrington Islands in 1949, 50 in Macleod Harbor, Montague Island in 1950, 150 between Johnstone Point and Bear Cape of Hinchinbrook Island in 1951, and 175–200 around Montague Island in 1955. In addition to the above reports, observations of smaller groups have been made in several areas: to the west as far as Elizabeth Island at the southern tip of the Kenai Peninsula, where 15 otters were observed in 1953, and to the east as far as the Copper River Delta where only a single animal was observed in 1950. An apparently distinct population of at least 100 animals is found at Kayak and Wingham Islands. My own observations verify many of these reports. It is likely that many groups of otters have not been seen because much of this area is remote and seldom traveled. Analysis of actual observations, however, indicates that the population of sea otters is at least 1,000 and possibly as great as 2,000 animals.

Kodiak-Afognak Archipelago.—Sea otters were observed in the Kodiak Archipelago as early as 1922 when Eyderdam (1933) saw four off Shuyak Island. Other early reports are available for several localities but none of these early observations were corroborated until 1948 when Refuge Manager Beals observed three animals off Shuyak Island. Chapados and Spencer, in aerial surveys of 1951, counted 15 animals on Sea Otter Island east of Shuyak and 67 among the Latax Rocks north of Shuyak. They found none in the Barren Islands or in the Trinity Islands. The 1957 surveys, however, confirmed the presence of otters in all three areas in far greater numbers than had been anticipated. The actual count, made partially from a boat and partially from the air, was 620 animals; this includes 14 in the Trinity Islands, 281 at Shuyak Island, and 325 in the Barren Islands. An aerial survey of the Shuyak area by Refuge Manager Troyer, in August 1958, resulted in a count of 591 animals or more than twice the 1957 count for the same area. In addition, local changes in distribution occurred between the two surveys. Because neither survey was complete, and because the distribution changes and the higher count may have involved movements from the Barren Islands to Shuyak, the differences in the two surveys cannot be resolved. Thus, my estimate of 800–1500 sea otters for the Kodiak Archipelago provides a conservative lower margin. It is based on estimates of 100–300 animals in the Trinity Islands, 400–700 at Shuyak Island and 300–600 in the Barren Islands.

Alaska Peninsula.—Four distinct population centers are found on the Alaska Peninsula: Augustine Island in Cook Inlet, Sutwik Island, the outer Shumagin Islands, and the Sanak-Sandman Reefs. These areas were the last of the productive hunting grounds and, as late as 1880, the Sanak area yielded over 2,000 skins annually (Petroff, 1884).

In 1948, a group of about 50 sea otters was reported at Augustine Island, and since then smaller groups have been reported from adjacent areas of the mainland coast from Shaw Island to Tuxendi Bay. D. L. Spencer counted 40 animals at Augustine Island and saw a single otter at Shaw Island during 1957 surveys. Although information on this colony is incomplete, it probably numbers at least 100–200 animals.

No otters were seen during the survey of the 180-mile long area from Cape Douglas to Cape Providence which separates the margins of the Augustine Island and the Sutwik Island populations. However, several sites in this area appeared to be favorable habitat, and considering recent trends in adjacent populations, establishment of resident populations should occur within a few years.

Verified reports of otters in the Sutwik area have been available since 1936, but it was not until the 1951 surveys by Refuge Manager Jones that sighting of 388 animals established the approximate distribution and size of the population. During the aerial surveys of 1957, 894 otters were counted, the greatest number between Sutwik Island and Cape Kumliun. The farthest west was at Katmai Reef off Cape Kumliun and the farthest east that otters were observed was in Chiginagak Bay. However, reliable reports indicate that a few animals are as far west as Castle Bay. The present distribution of otters in the central part of the Sutwik area is almost identical with that found by Jones in 1951, indicating the lack of major populations shifts. The periphery of the population, however, seems to be gradually expanding. Although the 1951 population figure may not be as accurate as that obtained in 1957 which more than doubles the former, the evidence indicates that this population is growing at a near maximum rate. The 1957 aerial counts are also considered low and I have estimated the population size to be between 1,000 and 1,250 animals.

The Shumagin Islands population is the largest that presently exists in the Alaska Peninsula area. As in the Sutwik area, the evidence suggests that it has been growing rapidly in the last few years. Occasional reports are available from the 1930's but Mr. Grundholt, a resident of the Shumagins for 80 years, says otters were seldom seen there before 1940. Recently, however, observations have become frequent, even among the northern islands. Scheffer in 1947 estimated the population at Simeonof Island to be 500 animals. David C. Hooper counted 633 otters on aerial surveys of Simeonof and Little Koniuji Islands in 1953, and on the basis of this count and his observations on other islands

in the Shumagins, estimated the total Shumagin population to be 1,000 animals. In the aerial surveys of 1957, 1,831 otters were seen and my estimate of the total population is 2,000–2,500 animals. The apparent increase in the short interval between the censuses of 1953 and 1957 is largely due to improved census techniques, but still a rapid growth in population and in the area it occupies seems evident.

A distance of about 50 miles separates the Sanak-Sandman Reef population from that in the Shumagins, but strays, probably most from the Sandman Reef population, have been observed at various points between. The history of this area provides an almost spectacular display of the reestablishment of otter populations. A diary that I examined of the late Mr. Bendickson, who lived on Cherni Island in the Sandman Reefs in the late 1920's, was complete to the extent that daily entries included weather records and observations on birds and animals—yet no comment was found on sea otters although they might be considered to have been of special interest. As early as 1922, however, Sanak residents reported otters among reefs north of that Island (McCraken, 1957). In 1948, Mike Uttecht of King Cove reported a group of 27 otters at Cherni Island. These animals may have come from one of the isolated islets in the Sandman Reefs or they may have come from the Sanak area. In 1951, Refuge Manager Jones surveyed the entire Sanak-Sandman Reef area by air and counted 65 otters in the Sanak Reefs and 97 otters in the Sandman Reefs. Between 1951 and 1957, reports from fishermen indicated an increasing number of otters in the Sandman Reef area and even on adjacent portions of the Alaska Peninsula. These observations were fully corroborated in the 1957 aerial surveys when 508 otters were counted in the Sandman Reefs and 251 in the Sanak Reefs. In the entire Sanak-Sandman Reef area the population is probably between 800 and 1,000 animals.

As was the case at Sutwik Island, the present distribution of otters in the central part of this area is similar to that which Jones encountered in 1951 and the trend has been for a gradual dispersion from the peripheries of the population. This pattern of dispersal is consistent with that of the Alaska Peninsula populations and may be expected to continue at an accelerated rate, so that within a few years the population may be continuous throughout the entire area.

Fox Island to the Islands of Four Mountains.—Only four reports of sea otters were found for this area prior to the July 1957 surveys and in each case the observations were of only a few animals. During the 1957 aerial survey of Unimak Island, 786 otters were encountered at a distance of 2 to 4 miles from shore between Cape Morvinof and Bechevin Bay, thus confining the earlier reports. No otters were observed near shore. Crew members of the M. V. *Deep Sea* also reported seeing this group at about the same location during summer months. In October 1957, Jones attempted to relocate this group of animals but was unable to do so although he extended his aerial search to a distance of 6 miles from land. A few days earlier I had seen only nine otters along the shorelines of the islands to as far west as Herbert Island. In late March 1958, Jones saw 20 otters in a cove at Cape Mordvinof, about 75 at Sennet Point in Unimak Pass, and 12 in the Krenitzin Islands. We can be reasonably certain that the group at Cape Mordvinof belongs to the population north of Unimak, but the group at Sennet Point may belong to the Sandman Reef population because, at the time they were observed, significantly fewer animals were present in the Sandman Reefs than were present in the summer. In 1949, Mike Uttecht reported that he had seen three to five otters on each of several summer trips along the north shore of Unimak but that he had not seen them on winter trips. His observations agree in general with the results of recent surveys. Available observations indicate that this group of sea otters spends a considerable part of the year at a greater distance from shore than is believed usual. Offshore movement is possible because of the extensive areas of shallow water north of Unimak where otters can obtain food. More observations are needed to ascertain the seasonal movements of this group in inshore and offshore areas.

Early in September 1957, Fisheries Research Institute Biologist Ronald Lopp observed 40 sea otters in the vicinity of Amak Island. Later, I accompanied Lopp on an aerial

survey of sea lions, *Eumetopias jubata,* between Cold Bay and Herbert Island in the Islands of Four Mountains, and although this flight was not entirely adequate as a sea otter survey, most of the immediate shoreline area was examined. Five otters were seen in the Krenitzin Islands, one at the east end of Unalaska Island and three near the west end of Unimak Island. None were found in the Islands of Four Mountains. Reports by residents of Akutan Village in the Krenitzin Islands, which we have received since the survey, indicate that there were more otters there than we discovered. The group seen by Lopp at Amak Island probably belongs to the offshore group seen north of Unimak Island but the animals in the Krenitzin Islands may be a distinct population.

Considering the vast area of shallow water north of Unimak which has not been surveyed, it is difficult to say how many animals were missed, but I suspect that the otters there were grouped and that we encountered most of them. My estimate for the combined populations is 1,100–1,500 animals. Interestingly, a range map for sea otter distribution in 1880 prepared by Petroff (1884) corresponds exactly with the present distribution for this area.

Andreanof Islands.—Groups of sea otters are present at the eastern end of Amlia Island and at Seguam Island in the eastern Andreanofs; a small group has been reported in the vicinity of Great Sitkin and Umak Islands, and large numbers of otters are found on Kanaga and Tonaga Islands in the western Andreanof. The populations at Amlia and Seguam Islands have not been surveyed but reliable reports of fairly large numbers of otters date from the 1930's. Strays from the Amlia group occasionally are seen as far west as Atka. In lieu of surveys, estimates of the number of animals present in this population are conjectural, but in view of our experience in other areas, I have concluded that the population on the two islands is between 1,000 and 2,000 animals.

At Great Sitkin and Umak Islands the information is even more fragmentary than that for Amlia and Seguam Islands. I have "guessed" that this population might contain as many as 200–500 animals.

On Tanaga and Kanaga, estimates of otter numbers are on safer grounds. The Murie Expedition encountered otters on both islands in 1936 and estimated the population at Cape Amagalik of Tanaga at 200 animals. Assistant Refuge Manager Hooper counted 571 otters on the southwestern third of Kanaga and about 1,000 between Cape Sasmik and Tanaga Bay on Tanaga Island in 1953. Both of these counts were made from the shoreline with binoculars. In 1954, I accompanied a Navy training flight on which it was possible to examine most of the shorelines of Kanaga and Tanaga. Although my counts were low, 471 on Kanaga and 324 on Tanaga, my general impression during the flight was that otters were about as numerous as they were on Amchitka Island. Karl W. Kenyon, on a similar flight in 1957, obtained a similar impression of abundance. Jones (1951), to indicate the general abundance of otters, calls the western Andreanofs, the Delarofs and the Rat Islands the "sea otter belt." During the 1957 surveys made from a dory, 566 otters were counted in a 19-mile sample area on the south side of Kanaga. The population on the eastern side of Kanaga, which was examined under less favorable conditions, appeared to be fully as large.

Estimates for the population on Kanaga can be derived in three ways: extrapolation of the 19-mile sample area figures to the entire island indicates a population of 3,430 animals; correction of the 1954 aerial survey figures on the basis of the 1957 surveys indicates a population of 3,600 animals; and applying density figures from Amchitka on the basis of square miles of water area less than 50 fathoms indicates a population of 4,000 animals. Because all these estimates are similar, I believe they may be close to the correct figure or somewhat conservative. Our records from Tanaga indicate that this population is similar to that on Kanaga and that we may use the same methods for its estimation. In round numbers, my estimate of the otters on Kanaga is 3,000–5,000 and on Tanaga 2,700–4,500. On Bobrof, a small island north of Kanaga, there are perhaps not more than 50–100 animals.

The first report of otters at Adak Island was of 14 animals in the straits between Adak and Kanaga Islands in 1943. R. D. Jones, however, observed no otters on dory surveys of

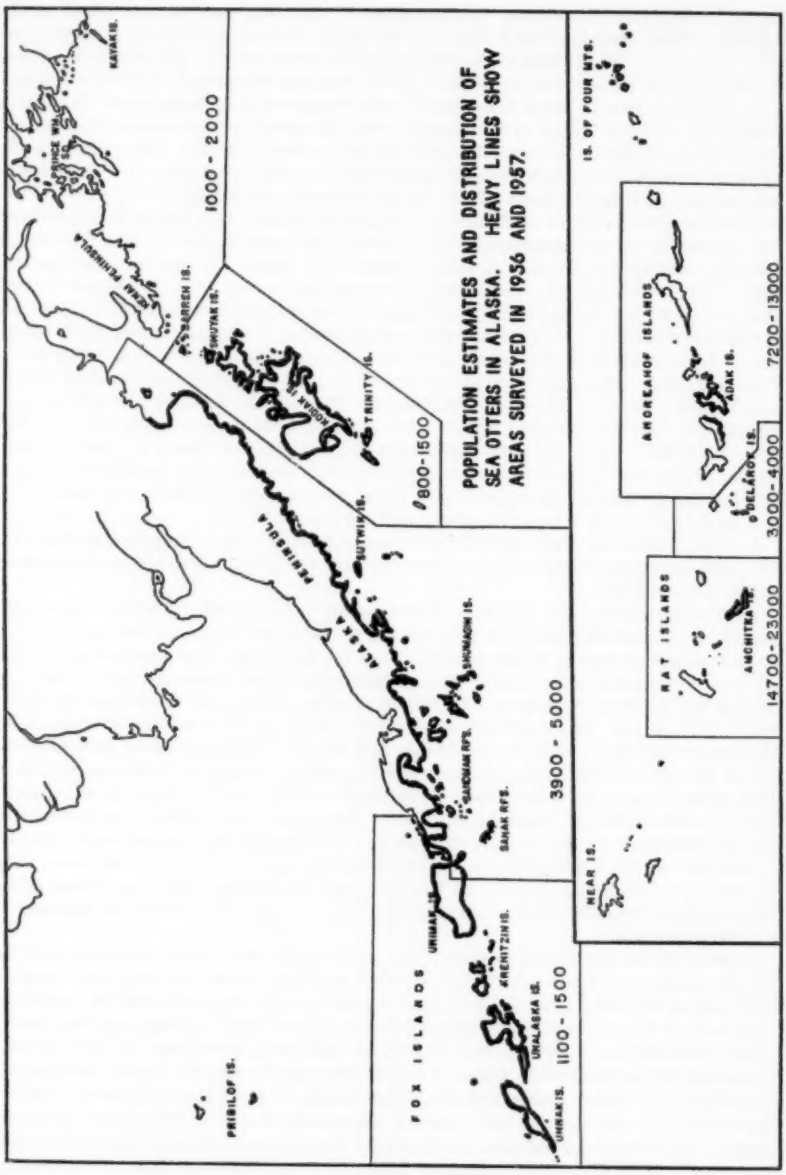


FIG. 1.—Distribution and abundance of sea otters in Alaska.

the west side of Adak in 1951 or of the entire island in 1952. In 1954, I saw 48 animals on the west side of Adak and since then otters have established a small colony in Kuluk Bay on the eastern side of the island. In surveys by dory with Refuge Manager Jones in 1957, we counted 399 animals and in addition found animals scattered across Adak Straits. The rapid increase of otters on Adak can have resulted only from immigration from Kanaga.

Delarof Islands.—The 11 small islands in the Delarofs have important numbers of sea otters. In 1936, Murie observed otters on all islands in this group with the exception of Amatignak Island, and Joynt saw otters on all islands during the naval patrol flights in 1943. Both Murie and Joynt observed large concentrations (50–150 animals) at Ogliuga and Kavalga Islands. On a partial aerial survey of the Delarofs in 1954, I counted 325 otters with the greatest concentration at Amatignak Island, where a single pod numbered between 150 and 250 animals. The early records of general abundance and my impressions from the 1954 survey indicate that the Amchitka figures may be safely extrapolated to the Delarofs. Using this basis, my estimate of the population falls between 3,000 and 4,000 animals.

Rat Islands.—Our record of sea otter populations on Amchitka Island, the most important of the Rat Island group, is long and reliable. Dufresne in 1931 and Hutchison in 1933 both estimated the population at 1,000 animals. Bureau of Fisheries Wardens stationed on Amchitka give population figures of 1,761 otters in 1937 and 1,870 otters in 1939. In 1943, Beals and Joynt counted 3,420 otters on Amchitka and 720 otters on Rat Island. In 1956, I counted 2,568 otters on the eastern half of Amchitka. Spot checks elsewhere and observations by Jones on the western end of the island indicated that this figure could be safely extended to the entire island. This gives an estimate of 6,000 to 8,000 animals.

Otters are also present on all other islands in the Rat Island group. The 1943 count on Rat Island by Beals and Joynt and 1949 counts by John Ball and Winston A. Elkins indicate that the population density there is comparable to that of Amchitka. Joynt says that in 1943 he found otters abundant on all islands seen but he did not examine Kiska because of Japanese gunfire. Again extending the Amchitka figure to the entire Rat Island group, we obtained an estimate of 10,000 to 20,000 animals.

In cases where I have extended Amchitka figures, I have done so on the basis of square miles of water area less than 50 fathoms, roughly the maximum depth at which otters appear to obtain food. This method is used rather than miles of shoreline because comparison of both methods for 10 segments of the Amchitka census area indicated that it was the best means of predicting the number of otters to be found in a given segment. Furthermore, I have used the actual count of otters on Amchitka rather than my estimate. Using this conservative figure for a midpoint, the upper and lower limits were obtained by arbitrarily adding and subtracting about 25 per cent.

Near Islands and Pribilof Islands.—The otters in both these areas were exterminated before 1900 and since that time have not been reported in either area. Sixteen otters were released in the Pribilof Islands in 1955 and six in the Near Islands in 1956, but they were not seen again.

Regional estimates of numbers of sea otters are summarized below, and these data are presented graphically in Fig. 1.

Cape St. Elias to the Kenai Peninsula	1,000– 2,000
Kodiak Archipelago	800– 1,500
Alaska Peninsula	3,900– 5,000
Fox Islands to Islands of Four Mountains	1,100– 1,500
Andreanof Islands	7,200–13,000
Delarof Islands	3,000– 4,000
Rat Islands	10,000–20,000
Total	27,000–47,000

DISCUSSION

The data from all recent observations and surveys point to the conclusion that the sea otter population has increased significantly in number and in extent within the last decade. This recent large increase is not the result of an increased rate of population growth but merely a reflection of the time the population has had to recover. As an example, it is unlikely that a small population of about 20 otters would be noticed in an area of several hundred square miles in the localities where most sea otters occur. Furthermore, if this population increased at an annual rate of 10 per cent, which Barabash-Nikiforof (1938) attributes to the sea otter, it would reach a total population of 384 in 30 years, but this number of animals scattered over a remote area still would be seldom observed. In another 20 years, however, with the same reproductive rate, the population would have reached 2,255 animals. They would be more apparent in areas of concentration and frequent strays might be expected at some distance from the parent colony. This hypothetical situation appears to fit the situation as we now find it in the Shumagin Islands and other localities along the Alaska Peninsula.

As a result of the large absolute increase in the population, we may expect that the *rate* at which sea otters disperse into unoccupied territory will be significantly greater than heretofore. This concept, however, can only be applied to the area from the Andreanof Islands eastward. To the west of the Andreanofs the habitat is limited—there is no place for expansion. There are definite signs that on Amchitka the population has reached the maximum level which the environment can support. In the reports of Loy and others between 1936 and 1940, there was no mention of mortality in otters, with the single exception of a comment by Gabrielson in 1939 that some pelts and skeletons had been collected on the Amchitka shore. Apparently these were so few that they caused no alarm. In 1949, ninety individuals were collected by Elmer C. Hanson and Robert D. Jones on Amchitka Island (Scheffer, 1951). This high mortality caused considerable alarm and gave much of the impetus to investigations carried on in recent years (Jones, 1951; Kenyon and Wilke, 1956; Rausch, 1953; Stullken and Kirkpatrick, 1955; Scheffer, 1951). Since 1952, about 75 sea otter carcasses have been found on the eastern end of the island each year, which indicates a minimum mortality of over 200 animals annually. This mortality appears to be primarily among the yearlings (those just independent of the female) and a few very old animals. David C. Hooper found no evidence of a mortality rate approaching that of Amchitka on either Tanaga or Kanaga in 1953 nor did we find any dead animals in the few miles of beach that we examined on Kanaga in 1957.

There are other indications that the Amchitka population has reached its saturation point. The various population estimates (which may be inaccurate) indicate a rate of increase of 19 per cent between 1933 and 1937, 15.7 per cent between 1937 and 1943, and only 5.8 per cent between 1943 and 1956. This decreased rate of growth in the population may be partly a reflection of the high mortality described above and partly as a result of a decrease in the reproductive rate. On Amchitka, in 1956, pups formed 14.9 per cent of the population; on Adak, in 1957, pups formed 21 per cent of the population and on Kanaga, 22 per cent.

The food supply may well be the factor limiting the population on Amchitka. Although otters appear to find sea urchins with ease, sea urchins to feed captive otters at Amchitka could be found only under the dock where the wild otters did not forage. Furthermore, the sea urchins we gathered and watched the otters eat on Amchitka are much smaller (younger?) than the sea urchins I have seen on Adak. On Amchitka, reltaively few empty shells were found on the beaches, but at Kanaga they were abundant and at Adak the bottoms of bays seemed almost to be paved with them in many places. In food habits studies of the sea otter, it has been shown repeatedly that the sea urchin is one of the most important food items (Jones, 1951; Murie, 1940; Williams, 1938). Also, on Amchitka I found it possible to distinguish areas frequented by females and young animals from those frequented

by males (almost all old animals) entirely on the basis of the relative amounts of mollusks and sea urchins found in fecal samples on the beach. Apparently older animals used shellfish extensively but young animals depended almost entirely on sea urchins. A diminishing supply of urchins, the post-spawning season of sea urchins when they are of less food value, the period of mortality in otters, and the fact that most mortality is in younger animals, all seem to be correlated. It is doubtful that acute starvation as such occurs, but lowered resistance as a result of food shortage and winter storms contribute cumulative stresses which result in death with typical symptoms of shock (Stullken and Kirkpatrick, 1955). The same factors may also result in a lower reproductive rate.

Nearly all descriptions of the sea otter's habitat emphasize the need for beds of kelp, and picture the otter in areas of rocky shorelines. This concept of habitat seems essentially true for Amchitka and many of the Aleutian Islands but falls far short of the total situation. The population north of Unimak Island was observed about 25 miles from any extensive beds of kelp. A similar situation may exist for the otters in the Trinity Islands. In addition, the sea urchin is probably not common on the sand or mud bottoms of these areas and it is possible that mollusks form the bulk of their food here. However, the food habits of these offshore populations are unknown.

The history and the present distribution of sea otter populations indicate that a fair measure of a region's capacity for otters is the amount of shallow water available (i.e., less than 50 fathoms). The present concentration points are all historically important hunting grounds. The fact that otters survived in these areas and not in others may be due not only to the quality of the habitat but also to the great expanse of shallow water which surrounds many of them and which may have prevented a systematic extermination by hunters located on the beach or by fleets of baidarkas working along narrow shoreline zones. In certain of the outer Aleutians the problem of logistics and the lack of harbors may have been equally as important as the above factors. For example, the otters were exterminated at Atka and Attu where harbors and a resident population of Aleuts were present, but in the Delarofs and at Amchitka harbors are fewer and there was no local Aleut population during the latter period of exploitation.

ACKNOWLEDGMENTS

Acknowledgments are due to Robert D. Jones, Jr., Karl W. Kenyon, Ford Wilke, David L. Spencer and Willard Troyer of the U. S. Fish and Wildlife Service and Charles M. Kirkpatrick of Purdue University for suggestions and for assistance in field work. One of our most difficult problems in the Aleutians was logistics. The generous cooperation of the U. S. Navy and of Naval personnel at Adak contributed substantially to our undertaking.

This work was supported by the Branch of Wildlife Research of the U. S. Fish and Wildlife Service, and in part by the Purdue Research Foundation, and is submitted as Journal Paper No. 1271 from Purdue University Agricultural Experiment Station.

SUMMARY

One hundred and seventy years of exploitation exterminated the sea otter in most of its original range, but small groups survived in widely scattered areas. In the aggregate these survivors may have numbered between 200 and 500 individuals. Since 1911, when protection was extended to sea otters, they appear to have increased at a rate which may be near their maximum capacity for recruitment. They may now number about 40,000 animals.

The present status of the otter is such that we can expect a rapid expansion in numbers from the Andreanof Islands eastward. West of the Andreanof Islands the habitat is limited and the population may already be near the carrying capacity. Here, sea otters are perhaps as abundant as they were before exploitation by the Russians. On Amchitka Island the evidence indicates that a high population has resulted in increased mortality and a lowered reproductive rate.

Both the historical and present distribution patterns appear to indicate that the primary factor in the sea otter's habitat is the amount of shallow water available in which the otter can obtain food. The evidence suggests that the coexistence of kelp and sea otters may be at least partially coincidental. However, reliable information on nearly all phases of sea otter ecology is lacking and present survey figures are not adequate. Population movements, seasonal and otherwise, are known to exist, but are not yet understood. Such movements could have an important bearing on population estimates.

LITERATURE CITED

ALLEN, GLOVER M. 1942. Extinct and vanishing mammals of the western hemisphere. Amer. Comm. for Internatl. Wildlife Prot., Spec. Publ. 11, 620 pp.

BARABASH-NIKIFOROV, I. 1938. The sea otter and stages of its study. Priroda, 2: 51–61.

EYDERDAM, W. J. 1933. Sea otters in the Aleutian Islands. Jour. Mamm., 14: 70–71.

HOOPER, C. L. 1897. A report on the sea otter banks of Alaska. U.S. Treas. Dept. Doc. No. 1977.

HOWAY, F. M. 1933. A list of trading vessels in the maritime fur trade, 1815–1819. Proc. and Trans. Royal Soc. Canada, Sec. 2, Ser. 3, 24: 111–134.

JONES, R. D., JR. 1951. Present status of the sea otter in Alaska. Trans. N. Amer. Wildl. Conf., 16: 376–383.

KENYON, KARL W. AND FORD WILKE. 1956. Sea otter studies in Alaska. 7th Alaska Science Conf., 6 pp., mimeo.

KHLEBNIKOFF, KIRYLL. 1835. Biography of Alexander Andreievitch. Baranoff: Governor-General of the Russian colonies in America. Navy Ptg. Off., St. Petersburg.

MARSH, M. C. AND J. N. COBB. 1911. The fisheries of Alaska in 1910. U. S. Bur. Fisheries, Doc. 746.

MCCRACKEN, H. 1957. Hunters of the stormy sea. Doubleday, New York, 312 pp.

MURIE, OLAUS J. 1940. Notes on the sea otter. Jour. Mamm., 21: 119–131.

PETROFF, I. 1884. Alaska: its population, industries, and resources. Tenth Census of the United States, Vol. 8, Govt. Ptg. Off., Washington.

RAUSCH, R. 1953. Studies on the helminth fauna of Alaska. XIII: Disease in the sea otter, with special reference to helminth parasites. Ecology, 34: 584–604.

ROQUEFEUIL. 1843. Voyage autour du monde. Vol. 2, pp. 308f, Paris.

SCHEFFER, V. B. 1951. Measurements of sea otters from western Alaska. Jour. Mamm., 32: 10–14.

STULLKEN, D. E. AND C. M. KIRKPATRICK. 1955. Physiological investigations of captivity mortality in the sea otter (*Enhydra lutris*). Trans. N. Amer. Wildl. Conf., 20: 476–494.

STURGIS, WM. 1805. Fur traders in the North Pacific. Pacific Coast MS K. 33., 35 pp.

WILLIAMS, C. S. 1938. Notes on food of the sea otter. Jour. Mamm., 19: 105–107.

Alaska Dept. of Fish and Game, Juneau. Received 27 February 1959.

AN ANALYSIS OF PARTURITION IN CHIROPTERA, INCLUDING NEW OBSERVATIONS ON *MYOTIS L. LUCIFUGUS*

By William A. Wimsatt

Despite a voluminous literature which has accumulated over nearly a century, our knowledge of reproduction in bats is still fragmentary (cf. reviews by Hartmann, 1933; Baker and Bird, 1936; Wimsatt and Kallen, 1952; Wimsatt and Trapido, 1952; Cockrum, 1955). The more fundamental aspects of reproductive physiology are virtually unknown, and only a handful of species have been studied at all intensively. Among the most neglected aspects of reproduction in bats is parturition. It has been observed in only a few species, the great majority belonging to a single family, the Vespertilionidae. Parturition is carried out in a remarkably similar manner in the various vespertilionids thus far studied, but differs in several respects from that of the few species of other families observed. There is a tendency among some zoologists to assume that the more familiar vespertilionid pattern is characteristic of the order as a whole, and it is evident that comparative observations are needed on additional genera and families. Furthermore, nothing whatever is known concerning the complex group of interrelated functions involved, on the one hand, in the stabilization of pregnancy and, on the other, in the upsetting of this stability to terminate gestation and initiate parturition. Their study would be of paramount interest in bats, for the group is characterized by small litters and newborn young of relatively enormous size and advanced degree of maturity.

For these reasons it was thought useful to assemble and analyze, from a behavioral and physiological point of view, all information presently available concerning parturition in bats. This study is intended to emphasize the limited scope of present knowledge of the subject and to focus attention on those behavorial and physiological aspects where additional and more meaningful observation and interpretation are desirable. In the portion of this paper which deals with the parturitional sequence itself, the subject will be presented chronologically, for this helps emphasize the dynamic nature of the process, enables comparisons between species to be made where they are most pertinent, and minimizes repetition.

Personal unpublished observations on parturition in the little brown bat, *Myotis lucifugus lucifugus,* made since the publication of an earlier brief description (Wimsatt, 1945) will be inserted at the appropriate places in the chronological account.

THE SOURCES

I have found in the literature 19 original descriptions of parturition in bats, but only a few of these deal with the entire sequence, or give reasonably complete details. In three cases the species observed are not recorded, and only the family is known in one of them. The remaining 15 accounts involve 5 families, 10 genera and 13 species. More specifically, parturition has been described in greater or lesser detail in 2 species which are completely unknown, 8 species (5 genera) of Vespertilionidae, 2 species (probably two different

genera) of Phyllostomidae, and 1 species in each of the families Pteropidae, Rhinolophidae and Molossidae.

Allen (1940) has summarized the observations of six earlier workers [Belon, 1555 (species unknown, but possibly a rhinolophid); Kuhl, 1817 (species unknown); Daniell, 1835 (*Nyctalus noctula*); Blake, 1885 (species unknown, but definitely a phyllostomid); Rollinat and Trouessart, 1896 (*Myotis myotis*); and Sherman, 1930 (*Myotis austroriparius*)] but records no personal observations. Eisentraut (1936) describes in detail the parturitional behavior of a vespertilionid bat, *Plecotus auritus*, and it is again summarized in his book which appeared the following year (Eisentraut, 1937*a*). Mohr (1933) and Wimsatt (1945) present details of the parturitional sequence in *Myotis lucifugus lucifugus*, and Goguyer and Gruet (1957) in *Myotis emarginatus;* Pearson, Koford and Pearson (1952) give a brief but lucid description of the process in *Corynorhinus rafinesquei intermedius*, and Orr (1954) has presented some observations on *Antrozous pallidus*. Ramakrishna (1950) has recorded details of parturition in *Hipposideros speoris* of the Rhinolophidae and *Cynopterus sphinx* of the Pteropidae. Knowledge of the phenomenon in the Phyllostomidae is very incomplete, being based on only two accounts (Blake, 1885—species unknown, but according to Allen (1940) probably *Eurohylla planifrons;* and Jones, 1946, in *Artibeus planirostris trinitatis*). Sherman (1937) appears to be the only person to have recorded details of parturition in the Molossidae, his observations relating to *Tadarida brasiliensis cynocephala*. Nothing is known concerning parturition in the remaining 12 families of Microchiroptera.

Photographic illustration of parturition has been found in only two places: Ramakrishna (1950) has published a photograph showing the head of a fetus protruding from the vagina of the magachiropteran *Cynopterus sphinx*, and Ryberg (1947) includes in his book 12 figures depicting various stages of parturition and the post-partum behavior of mother and young in the vespertilionid bat *Nyctalus noctula*. Unfortunately, most of the details are obscured by fingers, etc., for the animals were held in the hand of an observer while being photographed. Eistentraut (1936*a,b*) has depicted in a series of drawings the positions assumed by female *Plecotus auritus* during, and immediately after, delivery, and one of these has been reproduced by Bourlière (1954) in his recent book on the natural history of mammals.

THE TIME

The time of parturition may be considered from several points of view—time of year, time of day, or time in relation to fluctuations in metabolic activity or inherent activity rythms. A great deal is known about the first, very little about the second, and nothing at all in respect to the third.

In most bats thus far studied, parturition—like the over-all reproductive activity of which it is but a phase—is a seasonal phenomenon, the young being born at a time of year which is presumably most favorable for their nurture and survival. In temperate latitudes, both north and south, the time of parturition invariably falls in the spring or early summer, the later dates characterizing those species which dwell at greater extremes of north and south latitude. A remarkable fact is that some, and perhaps many tropical forms, which live throughout the year in a relatively constant environment (at least as regards length of day and temperature) likewise display seasonal reproductive activity, the time of parturition again most often falling during the period of the vernal equinox (cf. Baker and Bird, 1936; Baker and Baker, 1936). The factors regulating the reproductive periodicity of bats have not been determined and, as regards tropical forms, can scarcely be guessed at.

All known species of bats living nearer the extremes of habitable latitudes are monestrous, and parturition occurs but once each year—these include all of the familiar species of Europe and our own country. In the tropics, on the other hand, at least four polyestrous species are presently known, viz. *Nycteris luteola* (Matthews, 1941), *Carollia perspicillata* (unpublished personal observations), *Epomophorus anura* (Herlant, 1953) and *Desmodus*

rotundus murinus (Wimsatt and Trapido, 1952). Of these, only *Desmodus and Epomophorus* are definitely known *not* to display a "seasonally polyestrous" condition; they breed throughout the year, and parturition may occur in any month.

Many of the more familiar bats of the north temperature latitudes are colonial species, at least during the period of pregnancy and parturition (e.g., various species of *Myotis, Pipistrellus, Eptesicus, Corynorhinus, Tadarida,* etc.). In such monestrous species the colonial habit, and/or the enforced synchronization of vital processes in different individuals by external factors (such as the time of emergence from hibernation) to which all are subject, often predispose to a synchronization of reproductive processes, with the result that in any particular colony there is a distinct tendency for all individuals to become parturient at approximately the same time. There is some latitude, or course, but in most instances described parturition is usually completed within an entire colony in the brief span of a week or two (Wimsatt, 1945). Pearson *et al.* (1952) describe somewhat longer spreads of birth dates in various colonies of *Corynorhinus rafinesquei intermedius* in California, ranging from 19 days to 30–35 days. The longer spreads are attributed to the circumstance that ". . . different females roosted in different places at different temperatures before they congregated at the nursery colonies." That exposure of pregnant females (of heterothermic species, at least) to lower temperatures can slow fetal development, prolong pregnancy, and thereby delay the time of parturition seems clearly established from the work of Eisentraut (1937*b*) and Pearson *et al.* (1952). I have confirmed this also in *Myotis l. lucifugus,* in experiments in which development was delayed in pregnant females retained for variable periods at a temperature of 40°F (unpublished observations). The spread in parturition dates might be expected to be greater in tropical forms, especially those which are polyestrous.

Relatively little is known in reference to the time of day at which parturition normally occurs, or even whether it characteristically occurs at a particular time. The question is of theoretical interest, particularly in heterothermic species, for the latter have well-defined daily rhythms of activity (Pearson, 1947; Reeder and Cowles, 1951; Hock, 1951) which could conceivably influence, or be influenced by, the initiation of parturition. Little can be deduced from observations on captive animals, for such observations are too few, the conditions of artificial confinement may hasten or delay parturition, and the times specified in the literature indicate no specific pattern in any species. Parturition has been observed day and night in captive bats, often at different times of day in a single species. Since young bats are typically born in the daytime roost it can perhaps be assumed that parturition occurs sometime during the periods of inactivity, but whether the normal activity patterns of parturient individuals are modified in any way by the impending crisis is unknown. This would seem to be a problem most amenable to solution by careful observation of bats in their natural habitats under conditions which provide a minimum of disturbance.

THE SEQUENCE

Every account of parturition which I have found, except that of Goguyer and Gruet (1957), is based upon observation of pregnant animals removed from their natural habitat and brought into the laboratory or home for closer observation. This might not influence fundamentally the basic character of the process, but there is no doubt that nervous and physical strain induced by handling and malnutrition in many instances upset the normal time sequence of parturition, and often culminated in the death of the fetus before delivery was completed. Many bats appear to be extremely susceptible to premature abortion when handled or confined during the later stages of pregnancy. I have several times observed a majority of a group of females of *Myotis lucifugus* in advanced pregnancy abort their fetuses (usually stillborn) within a few hours of removal from a colony (unpublished observations). Harold Trapido (personal communication) has described similar experiences in Panama with newly caught pregnant specimens of *Chilonycteris rubiginosa* and *Pteronotus davyi* of the Phyllostomidae and *Molossus bondae* of the Molossidae. These and other

aberrant tendencies must be taken into account in judging the "normalcy" of parturitional phenomena in bats disturbed in, or displaced from, their natural habitats.

Behavior of Parturient Females

Several observers (Daniell, 1835; Whitaker, 1905; Sherman, 1937; Jones, 1946; Ramakrishna, 1950; Eisentraut, 1936; and Wimsatt, unpublished observations on *Myotis lucifugus*) have noted a change in the behavior of pregnant females approaching parturition. Individuals which had previously hung quietly in their cages suddenly became restless, changed their positions repeatedly, and displayed obvious signs of nervousness and irritability, accompanied in at least one instance by the utterance of a few notes as when irritated (*Tadarida brasiliensis cynocephala*, Sherman, 1937). The period of heightened activity, with one exception, was of relatively short duration, in most instances being noted as lasting no longer than a few minutes to an hour. The exception was a specimen of *Artibeus planirostris trinitatis* described by Jones (1946) in which the restless behavior persisted for nearly 24 hours—possibly an abnormal case. That it is not peculiar to any one group of bats is indicated by the fact that it has been recorded in eight species representing four families. The physiological basis and significance of this preparturitional nervousness is unknown for it precedes any external manifestations of the onset of labor. Nor is it known whether it represents a normal behavorial pattern among bats in the more familiar shelter of their natural environment, for the phenomenon has been described only in respect to caged animals.

A Question of Posture

In most but not all species of bats thus far observed, the female just before the onset of parturition assumes a characteristic posture which in many ways seems to facilitate the birth process and which, if she is not disturbed, she will maintain until parturition is completed, and sometimes for a variable period afterward. If hanging on a vertical surface, the bat reverses the normal position and suspends herself head upward, clutching the wall of the cage with the claws of the thumbs and feet, and usually with the hind limbs rather widely spread. At the same time the tail is strongly recurved ventrally so that the uropatagial membrane, stretched between the extended hind limbs and tail, forms a pouch-like receptacle into which the emerging young is conveniently received (Pl. I, 1, 2, 3). Since the umbilical cord before delivery of the placenta is delicate and quite easily ruptured, the delivery of the young into the pouched uropatagium minimizes the danger of premature rupture of the cord and possible dropping and loss of the newborn. On the other hand, if the female is hanging from a horizontal surface when parturition begins, a complete reversal of position is not possible. In these instances the female bends upward and grasps the surface by the thumbs so that she again effects a four-way suspension. In this position, too, the legs are widely spread and the tail is strongly recurved ventrally so that the uropatagium in conjunction with the plagiopatagium and trunk forms a commodious basket into which the newborn can be safely received (cf. Eisentraut, 1936*b* and Pearson *et al.*, 1952).

It is probably significant that all bats in which the foregoing postures have been observed (and in which the species is known) are vespertilionids, and comprise the following species: *Nyctalus noctula* (Daniell, 1835; Ryberg, 1947), *Myotis myotis* (Jobert, 1872; Rollinat and Trouessart, 1896), *Myotis lucifugus* (Mohr, 1933; Wimsatt, 1945), *Myotis austroriparius* (Sherman, 1930), *Plecotus auritus* (Eisentraut, 1936*a*,*b*), *Corynorhinus rafinesquei* (Pearson *et al.*, 1952) and *Antrozous pallidus* (Orr, 1954). A similar position of the female during parturition is described by both Belon (1555) and Kuhl (1817), but neither author identifies the species observed, although they were almost certainly either vespertilionids or rhinolophids (the bat was from Crete in Belon's case and Kuhl's specimen was from Germany).

That the parturitional posture described is not essential for birth, even in vespertilionids, is indicated by the observations of Whitaker (1905), Goguyer and Gruet (1957) and some of my own. Whitaker describes parturition in a specimen of *Pipistrellus* (=*Nyctalus*) *noctula* in which the bat hung across an upper corner of the cage head downward and gave birth to a young one in that position. The youngster clung to the fur of the mother and did not fall. Goguyer and Gruet induced a female *Myotis emarginatus* in a nursery colony to hang from a wire by her feet, whereupon she delivered a youngster in the normal inverted position. They suggest that retention of the resting posture during parturition may be normal in this species. I have observed females of *Myotis lucifugus* disturbed during parturition to break the typical posture and move about, sometimes assuming again the inverted position to complete the process and sometimes not. It would thus seem that the posture described is usual among vespertilionid bats during parturition but that under disturbed or crowded conditions delivery can be effectively accomplished while the mother is in other postitions.

In the relatively few instances in which parturition has been witnessed in bats of other families the mothers have not assumed the posture observed so frequently among the vespertilionids. In *Hipposideros speoris* (Rhinolophidae) and *Cynopterus s. sphinx* (Pteropidae) birth was accomplished while the females were hanging from the tops of their cages head downward in the normal resting position, the only concession to the process underway being a wider spreading of the legs than is normal for these species at rest (Ramakrishna, 1950). Sherman (1937) reports a similar retention of the normal resting position during birth in two specimens of *Tadarida brasiliensis cynocephala* (Molossidae) and he specifically mentions that there was no attempt to receive the young into the flight membranes. The small size of the uropatagium in *Cynopterus* and *Tadarida* would presumably render it of little value as a receptacle for the young in any event.

A slightly different posture during birth is described by Blake (1885), in a phyllostomid bat (species unknown). The mother hung free by one leg for several hours before and during the birth of the young one, the other leg being bent forward at right angles in front of the abdomen. This free leg was grasped by a hind leg of the fetus when it came free, and by gently raising her bent leg the mother appeared to draw the protruding portion of the body of the fetus upward, thereby assisting in its exclusion from the vagina. Blake's observations relate to but a single individual so it can only be a matter of conjecture whether the interesting sequence described is characteristic of the species observed or merely fortuitous. A similar retention of the normal head-downward position during parturition was noted by Jones (1946) in another phyllostomid, *Artibeus planirostris trinitatis*, and in his specimen too the female dropped one leg and bent it at the knee, but only after delivery was well underway. In this case the fetus came head first and the mother's free leg took no active part in delivery.

On the basis of present evidence the posture assumed by the mother during delivery would seem not to be determined by the presence or absence of a well-developed uropatagium. The reversal of position and pouching of the uropatagium described above has been observed only among vespertilionids and may represent a behavioral characteristic peculiar to this family.

Daniell (1935) mentions an anatomical peculiarity in the "pipistrelle" and "noctule" which he interprets as a functional adaptation to parturition. He notes that the os calcis, which extends along the margin of the uropatagial membrane toward the tail, is longer and coarser in the female than in the male, and he postulates that this provides greater tension to the pouched membrane at parturition. One may question this interpretation in respect to the primacy of the factor in parturition in light of other circumstances in which pouching of the uropatagium undoubtedly occurs in both sexes (e.g., in flight maneuvers and in restraining large insect prey) but it would be of interest to determine the validity of Daniell's observation of a sexual dimorphism of the os calcis in other vespertilionid bats. Jobert (1872) states that the curling of the uropatagium during parturition is assisted by the

contraction of numerous muscle bundles sandwiched between the epithelial layers of the thin membrane.

Labor

Detailed observations concerning labor in bats are relatively few, but at least some of its characteristics have been noted in several forms, notably in various species of *Myotis* (Jobert, 1872; Rollinat and Trouessart, 1896; Sherman, 1930; Wimsatt, 1945), in *Antrozous pallidus* (Orr, 1954), in *Tadarida brasiliensis cynocephala* (Sherman, 1937), in *Artibeus planirostris* (Jones, 1946) and in *Hipposideros speoris* and *Cynopterus sphinx* (Ramakrishna, 1950). The labor sequence appears to be essentially similar in all species observed, and consists in the main of moderate to violent contractions of the uterus accompanied by a tensing of the abdominal wall. The contractions are not rhythmic; they usually occur in series of three to six or more rapid spasms over a period of two or three seconds, each such series being separated by a variable rest interval of a few seconds to several minutes duration. In *Myotis lucifugus*, at least, during the intervals between contractions, one sometimes observes a marked quivering of the flanks and evidence of labored breathing (personal observations). Orr (1954) mentions a similar increase in respiration rate in *Antrozous pallidus* during labor spasms.

The duration of labor and the number of contractions necessary to expel the fetus have been recorded by several observers, and both can vary greatly, even within the same species. In the unidentified phyllostomid described by Blake (1885) labor and delivery required 35 minutes, and in *Artibeus planirostris* the entire sequence was accomplished in 20 minutes, of which the actual delivery occupied 9 minutes (Jones, 1946). In *Hipposideros speoris* labor and delivery required 38 minutes, and in *Cynopterus sphinx* the entire sequence took over 2¼ hours, delivery proper requiring 25 minutes (Ramakrishna, 1950). Sherman (1937), on the other hand, describes parturition in *Tadarida brasiliensis cynocephala* which was wholly completed in 1½ minutes! In a second specimen not observed continuously the entire sequence occurred sometime within 25 minutes separating two consecutive observation periods. All other observations of the time factor in parturition relate to vespertilionids. These may be summarized as follows: *Vespertilio* (=*Nyctalus*) *noctula*, 17 minutes (Daniell, 1935), and 4 minutes (Whitaker, 1905); the "murin", 3 to 4 hours (Jobert, 1872); *Myotis myotis*, approximately 30 minutes (Rollinat and Trouessart, 1896); *Myotis lucifugus*, variable, 15 to 30 minutes usual, but 5 minutes, 1½ hours, and 4 hours likewise recorded (Wimsatt, 1945); *Myotis emarginatus*, 15 minutes (Goguyer and Gruet, 1957); *Antrozous pallidus*, a few minutes to nearly 2 hours (Orr, 1954). All of the above species except *Antrozous pallidus* are normally monotocous. It is of interest to examine also the time factor in polytocous species. Sherman (1930) and Orr (1954) have provided the only data in such forms, *Myotis austroriparius* and *Antrozous pallidus*, respectively. *Myotis austroriparius* customarily bears 2 young, and *Antrozous pallidus* often does. In the majority of births witnessed in *Myotis austroriparius* the delivery of a single fetus was accomplished within 5 minutes or slightly more, but the interval between the delivery of the first and second fetus was 30 minutes in one instance and probably less than one hour in another. In the exceptional case of a "weakened" female, the delivery of the first fetus required 4¾ hours; delivery of the second began 39 minutes later and, after nearly two hours, was artificially terminated with the aid of forceps. In *Antrozous pallidus* the elapsed time between the birth of two young varied between 12 and 65 minutes.

It seems apparent from my observations on *Myotis lucifugus*, and those of others on other species, that the condition of the mother markedly influences the character of parturition. A weakened condition (induced, for example, by a refusal to eat) is most often associated with a prolonged and difficult delivery, and frequently culminates in the expulsion of a dead fetus. Animals which appear to be in good condition are almost invariably the ones in which labor is of shorter duration and delivery easier. It appears likely, therefore, that

under natural conditions parturition in bats is accomplished relatively rapidly, probably within a matter of minutes, and that the longer times recorded by many observers represent an abnormal response to handling and artificial confinement, complicated in many instances by malnutrition. In prolonged labor the number of muscular spasms experienced by the mother may be very great, and her apparent discomfort is likewise great (as noted by several authors). In shorter, and presumably more normal deliveries, as few as four series of contractions have sufficed to expel the fetus completely in *Cynopterus sphinx* (Ramakrishna, 1950) and ten in *Myotis lucifugus* (personal observation). Nearly all authors describe reactions of females in labor, such as cries, closing of the eyes, baring of the teeth, etc., which indicate that the muscular seizures are probably painful.

Several authors note that the position of the fetus *in utero* shortly before parturition is transverse (e. g., Sherman, 1937 in *Tadarida;* Jones, 1946, in *Artibeus*) and I have observed a similar orientation of near-term fetuses in various species of Vespertilionidae, Molossidae, Phyllostomidae, and in the vampire, *Desmodus rotundus.* It is therefore likely that a transverse position of the fetus preceding parturition is characteristic of all monotocous species. A feature of labor to which several authors likewise refer (and observed also by me in *Myotis lucifugus*) is a rapid shift of the fetus from the horizontal to the longitudinal position. Most often this seems to occur after labor contractions have begun, sometimes within minutes of delivery.

Movements of the fetus *in utero* are clearly detectable through the body wall. Jones (1946) describes convulsive movements of the fetus of *Artibeus planirostris* beginning several hours before the onset of labor and continuing through delivery. I have occasionally noticed the same thing in *Myotis lucifugus,* but only after labor had commenced. In most instances, however, fetal movements were not observed in *Myotis* before the body was partially extruded from the vagina. It is possible that earlier activation of the fetus, at least in *Myotis,* results from some abnormality, for in several instances it was clearly associated with unduly prolonged labor, and in one such instance the fetus was eventually born dead.

Delivery

Presentation of the fetus.—The most striking feature of delivery, noted consistently in the majority of species observed, is the breech presentation of the fetus (cf. Pl. I for details). Breech presentation seems characteristic of most vespertilionids, there being only three cases of head presentation recorded thus far in the literature, all of which involve *Nyctalus noctula* (Daniell, 1835; Whitaker, 1905; Ryberg, 1947). Ryberg does not actually describe the orientation at delivery, but the head presentation can be seen in figures 3 and 4 of his Plate 33. It thus appears probable that *Nyctalus noctula* consistently delivers its young head first, and in this respect the species provides an exception to the usual vespertilionid pattern.

Breech presentation has likewise been observed in members of other families of bats, i.e., in *Tadarida brasiliensis cynocephala* of the Molossidae (Sherman, 1937) and in the unknown species of phyllostomid described by Blake (1885). However, the only other birth of a phyllostomid on record, that of a specimen of *Artibeus planirostris trinitatis* (Jones, 1946), the fetus was born head first. Jones suggests that his case may have represented an abnormality, but he was apparently influenced in this by Blake's observation and the predominance of breech presentation in various vespertilionids. It is as logical to assume that Blake's case was abnormal, are even that his specimen was not a phyllostomid at all. Obviously, more observations are needed on the Phyllostomatidae before it can be determined whether either type of orientation is usual in the family or its major subdivisions.

The observations of Ramakrishna (1950) also indicate that a breech presentation may not be characteristic of all families of bats. He witnessed parturition in specimens of *Cynopertus sphinx* of the Pteropidae and *Hipposideros speoris* of the Rhinolophidae, and in each case the fetus was delivered head first.

It would be idle to speculate at present as to why a breech delivery is characteristic of so many bats whereas it is abnormal in most other mammals. It is my opinion, however, that the large size of the fetus, the shortness of the umbilical cord, and the relative paucity of amniotic fluid in late gestation would probably prevent any reversal of position of advanced fetuses *in utero*, and it seems reasonable to assume that the position of the fetus with the tail end oriented toward the corpus uteri is established not much later than mid-pregnancy. Before this time the amniotic fluid is copious, and the embryo does theoretically have room to rotate within the expanded amniotic sac, although the relative shortness of the umbilical cord would limit such movement in comparison with many other mammals. It follows from the above that the probable order of presentation at delivery can be inferred from the orientation of advanced fetuses *in utero*—a determination which could be made on newly collected pregnant specimens or those already preserved in spirits, a procedure which obviates the necessity of actually witnessing delivery under conditions where it is not feasible or possible to do so.

Participation of the fetus.—In most mammals delivery is a passive process as far as the fetus is concerned, the young being extruded from vagina fully enclosed within the amnion. Several observations suggest, however, that in some bats at least, the fetus may participate in its own delivery by movements which appear purposive rather than accidental. One case in point is the unknown phyllostomid described by Blake (1885) in which one foot of the emerging fetus grasped and held to a free leg of the mother and by means of this purchase assisted in freeing the remainder of the body from the birth canal. In the case of the head delivery of *Artibeus planirostris trinitatis* observed by Jones (1946) the fetus remained quiescent until the head and trunk had emerged (even though the amnion had been ruptured previously), at which time it suddenly became active and, gripping the fur of the mother with its thumb, freed its own feet. In describing parturition in *Vespertilio* (= *Nyctalus*) *noctula*, Daniell (1935) notes that the fetus, which was delivered head first, helped free itself by lateral movements of the wings. Even more overt actions have been observed in *Myotis lucifugus* (personal observations) and *Antrozous pallidus* (Orr, 1954). In general they consist of a groping extension of the hind limbs after these are freed from the birth canal, followed by grasping and pulling movements. The feet clutch whatever they en-

---

Figures 1 to 4 show successive stages in the delivery of the fetus. The "vespertilionid pattern" of birth, characterized by the inverted posture of the mother, the reception of the newborn into the pouched interfemoral membrane and the breech presentation of the fetus, is depicted in 1 to 3. In 1, only the interfemoral membrane and a portion of one hind limb have emerged. In 2, the entire body with the exception of the head has been extruded, and in 3 the head has just come free. The back of the newborn is toward the observer in all 3 figures (which record a single birth sequence involving a total time of approximately 15 minutes). Note that the amnion is no longer intact even in the earliest stage shown, and that in 3 the head of the mother is bent forward as she licks off the newly freed head of the young one. In 4, taken only a few seconds after 3, the mother has resumed the normal resting posture and is busily licking the body of the newborn. The sudden inversion of the mother prevented the youngster from gaining a firm hold, and it is seen dangling by the umbilical cord which leads to the undelivered placenta. The limbs of the baby are being extended in an effort to find an anchorage.

Figures 5 and 6 show certain post-partum events described in the text. In 5, the baby (arrows) has been tucked beneath the left wing of the mother, but it is still connected via the unsevered umbilical cord to the placenta within the birth canal. The mother is chewing at a segment of the ruptured amniotic membrane (•) which has been folded back over the cord. Figure 6 shows, from the dorsal aspect, a mother and her baby one day post-partum. The youngster is carried in the typical suckling position, tucked into a fold of the plagiopatagium along the line of its junction with the body, giving rise to the prominent bulge on the mother's right side.

PLATE I

Parturition in *Myotis l. lucifugus*. Legend opposite.

counter, usually the fur or a limb of the mother, but occasionally the support to which she is clinging. After purchase has been secured, the fetus flexes the legs with vigor and helps to draw its body from the vagina. In *Myotis lucifugus*, freeing of the trunk may be accomplished in only seconds, but usually progress is arrested at least momentarily at the stage where the head is still engaged. In a number of such cases I have seen the fetus bring the legs forward and push vigorously against the body of the mother in what appears to be a deliberate effort to free the head. When the latter does come free, whether with the assistance of the fetus or without, it does so suddenly, so it is clear that muscular spasms within the wall of the birth canal are not in abeyance. Orr (1954) has described similar pushing movements of the fetus during delivery in *Antrozous pallidus*, and Rollinat and Trouessart (1896) remark upon the great activity of the legs of the emerging fetus in *Myotis myotis*.

Early rupture of the amnion might be considered a prerequisite if the fetus is to participate actively in its own delivery. In most births thus far witnessed the observers have called attention either to the fact that the amnion was already ruptured when the fetus appeared or, more often, that the mother actively tore it at the first opportunity. In most cases (e.g., *Hipposideros speoris* and *Cynopterus sphinx*, Ramakrishna, 1950; *Myotis austroriparius*, Sherman, 1930; *Myotis lucifugus*, Wimsatt, unpublished observation) the membrane is torn with the teeth, but in a number of instances it was torn by scratching motions of a hind limb of the mother (e.g., in the unknown phyllostomid described by Blake, 1885; *Tadarida brasiliensis cynocephala*, Sherman, 1937). An associated activity noted by virtually all authors is the periodic licking by the mother of the body of the fetus as it emerges. In *Myotis lucifugus* I have gained the impression that this assists in the rolling back of the amnion (which may also be chewed upon and partially consumed) and it removes the (sparse) amniotic fluid which glistens on the freshly exposed surfaces of the fetus, for these licked surfaces assume immediately after licking a drier satiny luster. When the newborn is finally delivered it is again licked vigorously all over, an activity at which the mother may spend considerable time, sometimes alternating with cleaning of her own fur. This post-partum lavage has been recorded by nearly all authors and is possibly characteristic of all bats, as indeed it seems to be of most other mammals. Finally, the licking of the fetus during delivery may have stimulatory value in arousing it to activity, for in *Myotis lucifugus* the first movements of the fetus very often follow immediately upon the initial licking behavior of the mother (personal observation).

Delivery of the placenta.—In all bats, undoubtedly, the placenta is deciduate, and most authors record its delivery, usually some little time after the emergence of the fetus. But even in a single species the interval may vary widely and presumably is related to the general condition of the mother, the normalcy of the birth sequence, and perhaps other factors. The intervals recorded in various monotocous species include ½ hour and 2 hours in *Tadarida brasiliensis cynocephala* (Sherman, 1937), 4 hours in *Artibeus planirostris trinitatis* (Jones, 1946), 5 hours in *Myotis lucifugus* (Wimsatt, 1945), 3 to 6 hours in *Myotis emarginatus* (Goguyer and Gruet, 1957), 5 to 6 hours in *Hipposideros speoris* (Ramakrishna, 1950), and 9½ hours in an unidentified phyllostomid (Blake, 1885). Only Sherman (1930) has recorded the elapsed time between delivery and the emergence of the placentas in a polytocous species, *Myotis austroriparius*. In this form, which characteristically bears two young, the placenta of the first born may be delivered before the second fetus or, apparently more usual, both may be retained until after the two fetuses are delivered. In one case a dead fetus had been born and the mother was chewing the afterbirth when discovered. The second fetus was delivered (also still-born, and completely enclosed in the amnion which was not torn as is usual in a normal birth in this species) within 5 minutes, and the placenta appeared 2 minutes later. In a second case two viable fetuses were delivered, and after a lapse of over 4 hours both placentas appeared within a 10-minute interval. In a third case the placentas were delivered close together some 6 hours after the delivery of two living fetuses. While not without exception, it seems

probable that unusual delay (and perhaps unusual precocity) in the delivery of the placenta is more often than not associated with otherwise abnormal births.

The principal factor in the expulsion of the placenta is, in all probability, contraction of the uterine musculature, but one author (Jobert, 1872, in the "murin") describes a biting and pulling of the umbilical cord by the mother which he interpreted as a deliberate effort to dislodge the placenta and hasten its delivery. Actually, most species that have been observed bite and chew the cord, and it is conceivable that this sometimes places traction on the placenta, but it would perhaps be difficult at best to distinguish between these common actions and a purposive attempt to free the organ. Furthermore, a more rapid delivery of the placenta might be expected if there were a consistent effort by the mother to dislodge it. In a great many cases (e.g., in *Myotis lucifugus*, personal observation; *Myotis austroriparius*, Sherman, 1930; and others) the newborn young remain attached to the placenta via the umbilical cord for relatively long periods before the placenta itself is delivered and, during this time, by their vigorous movements stretch the cord and presumably exert a traction patently more forceful and continuous than that exerted by the sporadic biting movements of the mother.

Placentophagia.—The eating of the placenta by the mother following parturition is widespread among mammals and is by no means restricted to those of carnivorous habit. It is not surprising, therefore, that placentophagia has been observed among bats, both insectivorous and frugivorous species. What is of particular interest from several points of view is that the habit does not seem to be equally developed in all bats. It is unsafe to generalize from limited observations, but those available suggest that the afterbirth is consistently eaten by some bats, only occasionally by others, and perhaps not at all by still others. The behavior may even differ between the species of a single genus. A majority of authors who mention placentophagia actually witnessed the consumption of the placenta; others, unable to find the placenta following parturition, presume that it was eaten. In respect to most species our knowledge of the parturitional sequence is based upon a single observation, and even though placentophagia was observed, we gain no insight concerning the prevalence of the habit in the species described. In a few species parturition has been witnessed sufficiently often so that some reliance may be placed upon the consistency of the behavioral patterns noted. In only two species, however, are there supplementary observations, made in the natural habitat, which convey virtual certainty as to the normal behavioral pattern.

Consumption of the placenta by the mother has been witnessed in two phyllostomids (Blake, 1885, species unknown; Jones, 1946, *Artibeus planirostris*), one rhinolophid (Ramakrishna, 1950, *Hipposideros speoris*), and five vespertilionids (Wimsatt, 1945, *Myotis lucifugus;* Sherman, 1930, *Myotis austroriparius;* Pearson *et al.*, 1950, *Corynorhinus rafinesquei;* Daniell, 1835, *Nyctalus noctula;* Orr, 1954, *Antrozous pallidus*). In two births observed in *Myotis myotis* (Jobert, 1872; Rollinat and Trouessart, 1896) the placenta was not found subsequently, but was presumed to have been eaten, and a similar conclusion was reached by Goguyer and Gruet (1957) in respect to a specimen of *Myotis emarginatus*. In *Cynopterus sphinx*, parturition in which was described by Ramakrishna (1950), the fate of the placenta was not determined, and in *Tadarida brasiliensis cynocephala* the placenta was definitely not eaten (Sherman, 1937).

Sherman (1930) witnessed a reasonable number of births in *Myotis austroriparius*, and in each instance the placenta was promptly consumed, suggesting that placentophagia may be relatively constant in this species. However, in a closely related bat, *Myotis lucifugus*, the pattern is different, for the placenta was consumed only twice in over 12 births observed in their entirety (personal observations). In the remainder, the cord was not severed, and the placenta remained attached to the newborn for many hours until the dried cord ultimately broke, dropping the placenta to the floor of the cage. Mohr (1933), who also witnessed several births in this species, remarks that the placenta is not eaten and that it may remain attached to the newborn for as long as two days after delivery. Moreover, it is usual

to find fresh and dried placentas in large numbers beneath the roosting places of *Myotis lucifugus* when parturition is occurring in the colonies (Wimsatt, 1945). Collectively, these observations indicate that placentophagia is only sporadically indulged in by *Myotis lugifugus*, in contrast to the more constant behavior in the southern species of *Myotis* described by Sherman (1930). Another case is *Tadarida brasiliensis cynocephala*, in which the placenta was not eaten in the two instances in which parturition was observed (Sherman, 1937). Here, as in *Myotis lucifugus*, the placenta remained attached to the newborn, for 8 hours in one instance and 2 days in the other. The conclusion that the placenta is never eaten by this species would be unwarranted on the basis of two negative observations, but again field observations provide a clue, for Sherman notes that in colonies of *Tadarida* at parturition time "hundreds" of young are seen with the placentas still attached by means of the umbilical cord. It thus seems certain that placentophagia is not customary behavior in this molossid.

Orr (1954) witnessed a number of births in *Antrozous pallidus*, and records that the placenta was eaten on "several" occasions. He also makes the unique observations that in those cases where the placenta was not consumed the young were refused or killed by the mothers. He interprets the latter behavior as an abnormal condition induced by artificial confinement.

There is no general agreement concerning the over-all biological significance of placentophagia in mammals, and the observations to date on bats provide no additional insight. The behavioral implications can only be resolved on the basis of further observations made on a broad comparative front, and the physiological ones by basic laboratory studies involving biochemical, endocrinological, nutritional, and other fundamental aspects of the problem.

Development of the Fetus at Birth

Young bats are enormous at birth (in some species approximately 20 per cent or more the post-partum weight of the mothers) and, in comparison with the newborn young of many other mammals, are relatively mature. It would be of interest to contrast the ratios of individual and/or total fetal weight to maternal weight in polytocous and monotocous bats, for these factors could be related, as in certain other mammals, to some of the physical and physiological functions (e.g., a limiting distensibility of the uterus which leads to a decline in endometrial blood flow) believed to be involved in the termination of gestation and the initiation of parturition. It might be anticipated, by analogy with other mammals, that the fetuses would be relatively larger and more mature in monotocous bats than in polytocous ones. Few data are available for making reliable comparisons of this sort, but the following will illustrate what is meant.

Mohr (1933) gives 1.45 and 1.55 gms. as the weights of two newborn *Myotis l. lucifugus* (a monotocous species), and I secured an average of 1.70 gms. for three newborn specimens of the same species. The average weight of the three mothers was 6.5 gms. Assuming an average fetal weight of approximately 1.60 gms. and a maternal weight post-partum of 6.50 gms., the ratio of fetal weight to maternal weight is approximately 1:4.0. Sherman (1930) records the weights of two newborn littermates of *Myotis austroriparius* (a polytocous species which normally bears two young) as 1.10 and 1.15 gms. The mother weighed in at the same time at 7.25 gms. Assuming an average single fetus weight of 1.13 gms., the ratio to maternal weight becomes 1:6.4. The ratio of total fetal weight to maternal weight, however, increases to 1:3.2. Similarly, Lane (1946) gives weights of .93 and .96 gms. for two newborn young of *Pipistrellus subflavus*, another polytocous species which normaliy bears two young. The average weight of nine nursing mothers was 5.68 gms. From these figures the ratio of single fetus weight to maternal weight is 1:6.1, but the ratio of total fetal weight to maternal weight again increases, to 1:3.0.

It is evident that the individual fetus is relatively smaller in the polytocous bats (*M.*

austroriparius and *P. subflavus*) than in the montocous one (*M. lucifugus*), but that the total fetal burden is not too dissimilar in the three species. These data are merely suggestive, and comparable measurements on a larger series of animals would be required to establish the true relationship between fetal and maternal weights and the bearing of this factor on the termination of pregnancy. Equally desirable would be similar calculations based upon individuals of the same species having single and multiple births. In such cases careful attention should also be given to the relative degree of development of the young.

Another related factor is gestation length. As a general rule in mammals, fetal size and maturity at birth vary directly with gestation length, and within a given species larger litters tend to come to term earlier than smaller ones. The pattern in bats is consistent with the first, at least, for these animals not only deliver unusually large fetuses, but gestation is remarkably long for animals of their size (cf. Wimsatt and Trapido, 1952).

Most newborn bats seem capable of considerable independent activity and coordinated movements of the head and limbs, as attested by the alacrity and purposiveness with which they climb about on the body of the mother in their initial search for the mammae, activities that have been described by most authors cited earlier in this report. In their general bodily proportions, however, young bats are somewhat grotseque. Since there exist several excellent descriptions of newborn bats and the characteristics of post-natal development (e.g., Eisentraut, 1936*b*; Pearson *et al.*, 1952; Grassé, 1955; Sherman, 1930), I shall present here only a generalized description of the young at birth, emphasizing major points of similarity and difference between species.

The over-all bodily conformation of a newborn bat differs in several respects from that of the adult. The head, feet and thumbs are disproportionately large, a development which is no doubt related to the need for the immediate utilization of these members by the batlet as it seeks anchorage on the body of the mother. The proportions of the remaining parts of the wing are also distinctly different from those of the adult. The forearm is somewhat shortened, and the ulnar digits markedly so. The flight membranes are everywhere complete, but their proportional areas, especially in the interphalangeal regions of the wing, are substantially less than in the adult. In vespertilionids the ears are bent forward over the eyes at birth and remain in a floppy condition for some days post-partum (e.g., for 6 or 7 days in *Corynorhinus rafinesquei*, Pearson *et al.*, 1952; 8 to 10 days in *Antrozous pallidus*, Orr, 1954).

In the majority of species examined the eyes are closed at birth, and may remain so for as long as 8 to 10 days post-partum (e.g., *Nyctalus noctula*, Daniell, 1835; *Antrozous pallidus*, Orr, 1954; *Corynorhinus rafinesquei*, Pearson *et al.*, 1952). On the other hand, in *Tadarida brasiliensis cynocephala* the eyes may sometimes be open at birth (private communication of H. B. Sherman cited by Jones, 1945) and they seem invariably to be so in the phyllostomid bat *Artibeus planirostris trinitatis* (Jones, 1945, 1946). Jones also records, in respect to this species, that the eyes are already open in advanced fetuses *in utero* (and that the noseleaf of newborn individuals is as large as in the adult). According to Mohr (1933) the eyes of newborn *Myotis lucifugus* may open the second day post-partum, whereas in *Myotis austroriparius* they may not open for nearly a week (Sherman, 1930). These temporal variations could well be related to interspecific differences in the maturity of the fetus at birth.

In most newborn bats the body appears naked to the unaided eye, except for a few hairs on the face and extremities. An outstanding exception is *Artibeus planirostus trinitatis* in which, according to Jones (1946), the head, back, forearms and interfemoral membrane are covered with hairs, which are especially prominent after they have dried. In most species the trunk, especially on its ventral aspect, is reported to have a pinkish cast at birth but the skin of the muzzle, ears, flight membranes, limbs, and to a lesser extent the back, may be darkly pigmented (e.g., in *Myotis l. lucifugus*). Studies of the degree of ossification and other phenomena indicative of relative maturity of newborn bats have not as yet been made.

Post-partum Behavior

The post-partum behavior of mother and young, a subject to which most authors have contributed some observations, lies outside the primary scope of this review, so only brief consideration will be given to it. On the part of the newborn the initial behavior in all species seems most often to be an attempt to secure attachment to a nipple. In most bats the mammae lie in the axillary region, and immediately after delivery the newborn seizes upon the fur of the mother by means of the teeth, thumbs and feet and vigorously seeks out this area, more often than not assisted by nuzzling motions of the mother. Once attached to the mamilla the young one holds on tenaciously, and judging by the reactions of the mother, sometimes painfully. It is artificially detached with difficulty, and even violent movements (including flight) of the mother usually fail to dislodge it. The length of time a suckling youngster may remain thus attached is probably highly variable, depending no doubt on accidental circumstances and interspecific differences in behavior.

In many vespertilionids the body of the infant is oriented in parallel with that of the mother, and is tucked deeply into a fold of the plagiopatagium along the line of its junction with the trunk (Pl. I, 5, 6). This disposition has been noted often enough in various vespertilionids to be considered characteristic, and it is one which would appear to interfere least with the movements of the mother. Observations on other groups of bats are fragmentary and it is still unknown whether the suckling young are carried in some characteristic way.

In some respects the reactions of the mothers to their newborn young are similar in all bats, but in others there may be interspecific differences. The tearing of the fetal envelopes, the periodic licking of the emerging infant, and the thorough post-partum lavage already described have been observed in virtually all groups. A noteworthy exception is *Tadarida brasiliensis cynocephala*, in which, according to Sherman (1937), the young were received with relative indifference by the mothers in the two births he witnessed. Apparently the young were neither licked nor assistd in their search for the mammae. It is unknown whether this apparent indifference is characteristic of *Tadarida* in its natural environment, or in general to what extent the behavioral pattern of the mother is influenced by the relative degree of maturity of the fetus at birth.

MISCELLANEOUS PHYSIOLOGICAL CONSIDERATIONS

The basic physiology of parturition in bats is undoubtedly as complex as in other mammals, but remains at present wholly obscure. We are, for example, in complete ignorance concerning the role of the endocrine glands in the process, and whether or not the placenta has endocrine functions. We have no knowledge of the hemodynamics of the placental or uterine circulations, nor of antecedent or concomitant changes in them during parturition. Changes in the pelvis to accommodate or facilitate the passage of the relatively enormous fetus have been investigated to my knowledge in only one species, *Corynorhinus rafinesquei intermedius* (Pearson *et al.*, 1952). These and many other physiological aspects must await future investigation. In this final section I shall include a few miscellaneous observations of a physiological nature which could not logically be fitted into the chronological arrangement of the preceding section.

Effects of Oxytocin

Hormonal influences of hypophyseal, ovarian and/or placental origin are known to be involved in the initiation of parturition in many mammals. Among the pituitary factors, oxytocin is believed to have a direct effect on the uterus. On three occasions I attempted to hasten the onset of parturition in specimens of *Myotis l. lucifugus* judged to be at term, by administering a single intraperitoneal injection of 2.5 units of oxytocin (Armour).[1] In

[1]The oxytocin used was obtained through the courtesy of Dr. Irby Bunding of the Armour Research Laboratories, Chicago.

each case uterine contractions (visible through the abdominal wall) were elicited within a few minutes, and delivery of the fetus commenced immediately thereafter. The consistency of the results probably indicates that oxytocin can stimulate contraction of the uterine smooth muscle in *Myotis* but, while the results are suggestive, it cannot be definitely concluded merely on the basis of these preliminary experiments that a posterior hypophyseal principle is normally involved in parturition in this bat.

Umbilical Cord

In most bats of which I have examined pregnant specimens (*e.g., Rhynchiscus naso, Noctilio labialis, Artibeus jamaicensis, Desmodus rotundus, Myotis lucifugus, Tadarida brasiliensis*) I have been impressed with the relative shortness of the umbilical cord as seen *in utero*. In an analysis of comparative umbilical cord length and factors effecting it in eutherian mammals, Starck (1957) presents data on the relative lengths of the umbilical cord in relation to body length of the fetus in seven species of bats representing six families and both suborders. Cords having a relative length of 30 per cent of the trunk length ("Rumpflänge") he designates as "short," 75–100 per cent or more as "long." He records that the cord is "long" in *Pteronotus, Desmodus* and *Myotis,* intermediate in *Rhinolophus, Molossus, Rousettus* and *Pteropus,* and too variable to be classified in *Phyllostomus* and *Glossophaga.* It should be noted that the range of percentages recorded was great between individuals of a single species, viz., 62–100 in *Pteronotus,* 47–86 in *Desmodus,* 75–114 in *Myotis,* 40–65 in *Rhinolophus,* 28–94 in *Phyllostomus* and 36–70 in *Glossophaga.* The conditions under which the cords were measured were not stated.

Generally the umbilical vessels tend to follow a relatively straight course, lacking the spiraled arrangements so common in the relatively longer cords of various other mammals. Further, the cord is remarkably elastic; one has only to observe the stretching which it undergoes when the newborn bat is moving about on the venter of the mother before the placenta is extruded from the birth canal to appreciate this fact (Pl. I, 5). In some species the cord is severed by the mother early, or later before the delivery of the placenta, but in *Myotis lucifugus* (personal observations) and in *Myotis austroriparius* (Sherman, 1930) and *Myotis emarginatus* (Goguyer and Gruet, 1957) usually this does not occur, and the young may be "leashed" via their cords to their undelivered placentas for shorter or longer periods (Pl. I, 4). Sherman's (1937) observations indicate that this commonly occurs also in *Tadarida brasiliensis cynocephala.*

There is some evidence in the literature and from personal observations that accidental and premature rupture of the umbilical cord may be deleterious to the newborn. Ramakrishna (1950) describes an incident in which a newborn specimen of *Cynopteris sphinx,* still attached via the cord to the undelivered placenta, lost its hold on the mother and dropped, snapping the cord near the umbilicus. The fetus immediately began to hemorrhage from the umbilicus and died within a few minutes. Sherman (1930) describes a similar occurrence in *Myotis austroriparius,* in which one of two young was found dead shortly after delivery from loss of blood from a ruptured cord. On two occasions in *Myotis l. lucifugus* I have seen the umbilical cord accidentally snapped a few moments after delivery; in each case profuse bleeding occurred from the ruptured end attached to the fetus, and death ensued in a matter of minutes. In a third case the cord was deliberately cut, and again there was profuse bleeding and rapid demise of the newborn.

These experiences led me to observe the cord closely for a period of time after each of three deliveries, all apparently normal. The results were similar in each case. Immediately after delivery of the fetus, and for a period of 3 to 10 minutes thereafter, the cord presented a turgid appearance and was bright red in color, indicating that the circulation was still free and open through the umbilical vessels. This was true even when the cord was stretched by movements of the fetus. Following this period, and over an interval of only a few minutes, the cord experienced a rapid blanching, tending now to become whitish in color,

and its girth likewise diminished. These changes marked the cessation of the umbilical circulation. During the period when the umbilical circulation was still intact the mother often licked the cord and cleaned it (by pulling and chewing movements) of adherent folds of the ruptured amniotic sac (Pl. I, 5). After the cord had blanched, the female generally gave it no further attention and, being a tenuous structure, it rapidly desiccated, assuming in the process a translucent brown color. It would appear, therefore, that in *Myotis lucifugus*, and perhaps in other species, delivery of the fetus is not in itself an immediate stimulus for the physiological closure of the umbilical circulation. In those species in which the female does not immediately sever the cord, this behavior might be related to an inherent delay in the closure of the vessels. On the other hand, sometimes in *Myotis lucifugus* and perhaps more regularly in other species, the female may sever the cord fairly promptly following delivery of the fetus without deleterious effects. In such cases the repeated trauma to the umbilical vessels associated with the chewing of the cord may provide an immediate mechanical stimulus for their contraction, leading to a more prompt cutting off of the blood flow within the cord.

Changes in the Pelvis

The relatively large size of bat fetuses at birth leads one to suppose that extensive changes in the pelvis of pregnant females may be necessary to facilitate the passage of the fetus at parturition—a phenomenon which is well known in certain other mammals. However, in the only instance in which data are available, this seems not to be the case. Pearson *et al.* (1952) have explored this problem in *Corynorhinus rafinesquei intermedius* and have found that while ". . . there is some resorption of bone in the pubic region during pregnancy, as well as a thinning and an attenuation of the pubic bones to form a keel [there is at no time in the female] a bony symphysis pubis to be 'relaxed' . . . ." They did note, in addition, that the pubes begin to "flare outwards" during pregnancy. According to Grassé (1955) a bony symphysis pubis is characteristically lacking in bats, the pubes being united merely by a fibrous or fibro-cartilaginous strand of tissue. Whether such a union actually exists in vespertilionids appears not to be definitely known; all illustrations and skeletal preparations I have seen fail to show any sort of connection between the pubic bones in the symphysis region. On the other hand, in a carefully prepared skeleton of *Desmodus rotundus* in my possession, a fibrous or fibro-cartilaginous connection is very prominent, and in another, of *Phyllostomus hastatus panamensis*, there is not only a prominent bridge between the pubes, but it appears osseous. It is conceivable that if such a bridge exists in vespertilionids and other small bats it may be so delicate as not to withstand the relatively rough handling involved in the preparation of skeletonized material. Histological sectioning or *in toto* staining of cleared whole pelves may be necessary to resolve the issue. In any event the real point is that in the absence of such a connection, attenuation of the pelvic bones and a flaring out of the pubes during pregnancy would certainly facilitate the birth process, and the type of changes described by Pearson *et al.* (1952) in *Corynorhinus* might well be characteristic of other small bats. In larger species in which the pubes are definitely joined by a fibrous, fibro-cartilaginous, or even osseous strand, this tissue should be examined for qualitative or quantitative changes associated with impending parturition, for it delimits the pelvic outlet ventrally, and in non-pregnant females the pelvic canal appears too small to permit the passage of the large fetus. "Relaxation" changes could as well occur in ligamentous structures as osseous ones, and there is no reason to assume that a non-osseous symphysis is any less susceptible to endocrine modification than a bony one. Whether or not the ovaries of bats produce the non-steroidal "relaxation" principle (relaxin), however, remains to be investigated.

SUMMARY

Parturition represents one of the most neglected aspects of reproduction in the Chiroptera. This study brings together for analysis all of the relatively meager information on the subject.

The phenomenon is discussed from both a behavorial and physiological point of view. The need for broader comparative studies is emphasized, and attention is focused on behavorial and physiological problems requiring more penetrating study in the future. The parturitional events are analyzed in the chronological order of their occurrence, and unpublished personal observations on various phases of parturition in *Myotis l. lucifugus* are included in the appropriate sections. It is hoped that this analysis will prove useful to zoologists who will in the future have the opportunity and interest to shed further light on this important phase of the reproductive life of bats.

LITERATURE CITED

ALLEN, G. M. 1940. Bats. Harvard Univ. Press, Cambridge, 368 pp.

BAKER, J. R. AND Z. BAKER. 1936. The seasons in a tropical rain-forest (New Hebrides). Part II. Fruit-bats (Pteropidae). J. Linn. Soc. London, 40: 123–141.

———. AND T. F. BIRD. 1936. The seasons in a tropical rain-forest (New Hebrides). Part 4. Insectivorous bats (Vespertilionidae and Rhinolophidae). J. Linn. Soc. London, 40: 143–161.

BLAKE, H. A. 1885. Note on parturition of a West Indian bat. Sci. Proc. Roy. Dublin Soc., 4: 449–450.

BELON, P. 1555. L'histoire de la nature des oyseaux, avec leurs descriptions et naifs portraicts retirez du naturel; eserite en sept livres. Paris I (33), 381 pp.

BOURLIÈRE, F. 1954. The natural history of mammals. Knopf, New York, 363 pp.

COCKRUM, E. L. 1955. Reproduction in North American bats. Trans. Kansas Acad. Sci., 58: 487–511.

DANIELL, G. 1835. On the habits and economy of two British species of bats (*Vespertilio pipistrellus*, Geoffr. and *Vespertilio Noctula*, Schreb.). Proc. Zool. Soc. London, 2: 129–132.

EISENTRAUT, M. 1936. Die Fortpflanzungsbiologie der Fledermäuse. Ztsch. Morp. u. Ökol., 31: 27–63.

———. 1937*a*. Die deutschen Fledermäuse: einie biologische Studie. Schöps, Leipzig, 184 pp.

———. 1937*b*. Die Wirkung niedriger: Temperaturen auf die Embryonalentusicklung bei Fledermäusen. Biol. Zentralblatt, 57: 59–74.

GOGUYER, G. AND M. GRUET. 1957. Observation d'une parturition chez *Myotis emarginatus*. Mammalia, 21: 97–110.

GRASSÉ, P. P. 1955. Ordre des Chiroptères. *In* Traite de Zool., 17: 1729–1806, Masson et Cie, Paris.

HARTMANN, C. G. 1933. On the survival of spermatozoa in the female genital tract of the bat. Quart. Rev. Biol., 8: 185–193.

HERLANT, M. 1953. Étude comparative sur l'activité génital des Chéiroptères. Ann. Soc. Roy. Zool. Belg., 84: 87–116.

HOCK, R. J. 1951. The metabolic rates and body temperatures of bats. Biol. Bull., 101: 289–299.

JOBERT, C. 1872. Études d'anatomie comparée sur les organs du toucher chez divers mammifères, oiseaus, poissons et insects. Ann. Sci. Nat., Ser. 5, Zool., 16: 1–162.

JONES, T. S. 1945. Unusual state of birth of a bat. Nature, 156: 365.

———. 1946. Parturition in a West Indian fruit bat (Phyllostomidae). J. Mamm., 27: 327–330.

KUHL, H. 1817. Die deutschen Fledermäuse. Hanau, pp. 1–67, pl. 23–25.

LANE, H. K. 1946. Notes on Pipistrellus subflavus subflavus (F. Cuvier) during the season of parturition. Proc. Penn. Acad. Sci., 20: 57–61.

MATTHEWS, L. H. 1941. Notes on the genitalia and reproduction of some African bats. Proc. Zool. Soc. London, Ser. B, 111: 289–346.

MOHR, C. E. 1933. Observations on the young of cave-dwelling bats. J. Mamm., 14: 49–53.

ORR, R. T. 1954. Natural history of the pallid bat, Antrozous pallidus (LeConte). Proc. Calif. Acad. Sci., 4th Ser., 28: 165–246.

PEARSON, O. P. 1947. The rate of metabolism of some small mammals. Ecology, 28: 127–145.

———, M. KOFORD AND A. K. PEARSON. 1952. Reproduction of the lump-nosed bat (*Corynorhinus rafinesquei*) in California. J. Mamm., 33: 273–320.

RAMAKRISHNA, P. A. 1950. Parturition in certain Indian bats. J. Mamm., 31: 274–278.

REEDER, W. C. AND R. B. COWLES. 1951. Aspects of thermo-regulation in bats. J. Mamm., 32: 389–403.

ROLLINAT, R. AND E. TROUESSART. 1896. Sur la reproduction des chauves-souris. Mém. Soc. Zool. de France, 9: 214–240.

RYBERG, O. 1947. Studies on bats and bat parasites. Svensk. Natur., Stockholm, xvi + 330 pp., 55 pl.

SHERMAN, H. B. 1930. Birth of the young of Myotis austroriparius. J. Mamm., 11: 495–503.

———. 1937. Breeding habits of the free-tailed bat. J. Mamm., 18: 176–187.

STARCK, D. 1957. Ueber die Länge der Nabelschnur bei Säugetieren. Ztsch. f. Säugetierkunde, 22: 77–86.

WHITAKER, A. 1905. Notes on the breeding habits of bats. Naturalist, Lond., 325–330.

WIMSATT, W. A. 1945. Notes on the breeding behavior, pregnancy and parturition in some vespertilionid bats of the eastern United States. J. Mamm., 26: 23–33.

———. AND F. C. KALLEN. 1952. Anatomy and histophysiology of the penis of a vespertilionid bat, Myotis lucifugus lucifugus, with particular reference to its vascular organization. J. Morph., 90: 415–466.

———. AND H. TRAPIDO. 1952. Reproduction and the female reproductive cycle in the tropical American vampire bat, Desmodus rotundus murinus. Amer. J. Anat., 91: 415–446.

[Supported in part by a research grant (G–2188) from the National Science Foundation and in part by the Sage and Sackett Research Funds of the Department of Zoology.]

Dept. of Zoology, Cornell University, Ithaca, New York. *Received 27 February 1959.*

OBSERVATIONS ON THE ECOLOGY OF THE JAPANESE PIKA

BY RYOICHI HAGA

Pikas are found from Europe to Japan, from the Himalayas to northern Siberia, and in western North America. Fossil remains have also been found in England, France and Germany (Tate, 1947). The discovery of pikas in Japan is a comparatively recent event. They were first found in Okedo, in the Kitami District, in 1928. Subsequent studies at the Zoological Institute of Hokkaido University led to reports on their ecology and distribution by Inukai and Shimakura (1930) and Inukai (1931*a*, 1931*b*, 1932).

The Japanese pika, *Ochotona hyperborea yesoensis* Kishida, has apparently lived in the Hokkaido area since the diluvial epoch, but since pikas are mostly restricted to inaccessible talus slopes and forest zones in the alpine area of this region, they have been studied very little. Recently, however, as the development of the resources of Hokkaido has progressed, the habitat available to pikas has been greatly reduced and, at the same time, their habits have also become better known. Pikas have been reported as common in Okedo, Shikaribetsu, the Mt. Taisetsu Range, Mt. Yubari, Mt. Ashibetsu and the Hidaka Range until recently. Now they are seldom seen in the vicinity of Mt. Yubari and Mt. Ashibetsu, except in very remote and restricted areas. However, where they have invaded new habitats in the Rubeshibe area of Kitami, and through Sounkyo and Okedo of the Mt. Taisetsu Range, they are quite abundant and have become pests in larch afforestations (Tomoda, 1956; Haga, 1957).

The Veterinary Section of the Institute of Infectious Diseases, Tokyo University, have turned their attention to the development of the pika as a new laboraory animal. We have taken charge of the capture and care of the animals, and this paper is a report on their habits and ecology as we have observed them.

Habitat preference.—Pikas are thought to be animals of the Alpine region. In the Himalayas they are found only in the mountains at altitudes of 8,000 to 18,000 feet, but in northern Siberia and the Saghalien they are found almost at sea level, so altitude, as such, is not a limiting factor.

The most important factor governing habitat distribution seems to be the nature of the terrain. Pikas live on talus slopes in the natural crevices among the rocks, and the conditions provided by such terrain seem to be ideally suited to their physiological needs. Population density is influenced by the quantity of vegetation, but not by the local abundance of any particular plant species. As will be pointed out in a later section, pikas eat a wide variety of plant species, so that the amount but not the kind of vegetation may be limiting.

Temperature observations made in habitats at Rubeshibe, Mt. Taisetsu and Shikaribetsu are shown in Table 1. During the summer months pikas show a preference for cool parts of the habitat. At this time of the year, burrow

TABLE 1.—*Temperature relations in pika habitats at Okedo, Kitami District*

	SLIDE ROCK			FOREST ZONE		
	6:55 AM	12:20 PM	3:50 PM	6:50 AM	12:15 PM	3:45 PM
Air temperature, °C.	14.0	26.0	18.0	12.0	19.0	16.0
Burrow temperature (entrance)	13.5	19.0	16.0	13.0	17.0	14.5
Burrow temperature (1.4 to 1.6 m. depth)	11.5	11.0	14.5	13.0	14.0	14.0

temperatures are considerably lower and show less diurnal fluctuation than do air temperatures above ground. Snow cover provides insulation against extreme cold during the winter.

Humidity measurements were not taken, but habitats in which observations were made were usually damp and were characterized by plant species which prefer moist environments. The pikas showed no strong preference for a dry environment, except in the case of nest sites.

General behavior.—Pikas are especially active at dawn and in the evening, although they may be active at any time during the day or night under certain conditions. They seem to prefer cool temperatures, and will suddenly appear above ground during the day if there is a heavy fog, or in response to a drop in temperature. They are seldom out on rainy or cold, windy days, however.

Pikas spend more than half the year under snow but do not hibernate. They are active on the surface of the snow until the snow depth reaches 20–30 cm. In deep snow they dig tunnels about 5–6 cm. in diameter and move freely through these tunnels or through rock crevices.

Natural nests have not been found in Japan. A nest made in an outdoor cage at the Zoological Institute was saucer-shaped, 16–20 cm. in diameter and 6 cm. thick. The nest was rather crudely constructed with layers of hay at the bottom and dry moss in the middle. It was located 50 cm. below the surface of the rocks and covered loosely with dry leaves.

The pika is often called "the piping hare" because of its sharp, metallic cry, *kichii, kichii.* It also utters another warning cry, *pirrrr,* but rather infrequently. The call of the pika is most often heard at dusk or dawn or on foggy days during the summer. It seldom calls during the snow season and calls very little in spring and autumn. Of the 12 captive animals observed at the Zoological Institute, the adults seldom called but some of the juveniles called frequently. Aside from warning, I am not sure that these calls have any other social significance.

Pikas are reported to have a strong social life. Dixon (1931) and Hamilton (1939) state that they cooperate with each other when threatened by predators. I have often seen least weasels (*Mustela rixosa namiyei*) and Siberian ermine (*Mustela erminea orientalis*) near pika burrows, but the only cooperation shown by the pikas was in their warning cries. When pikas are caged together they fight until one, usually the male, is killed.

Feeding behavior.—The food habits and food hoards of pikas have been described by Bailey (1931), Hamilton (1939), Loukashkin (1940), Anthony (1928) and Hayward (1952). There are reports on the food habits of the Japanese pika by Inukai (1931*a*), Kishida (1933) and Sakagami, Mori and Kikuchi (1956). Since the object of this study was the domestication of the pika as a laboratory animal, particular attention was paid to their food habits.

A list of plants found in the food stores of pikas is shown in Table 2. The plants that are stored vary with the habitat and species available, but each of the species shown in Table 2 was eaten when fed to captive pikas. From the

wide variety of species included in this list, one may conclude that pikas are relatively unselective and it is not surprising that they cause considerable damage in spruce and larch afforestations when snow is on the ground and other plants are scarce (Haga, 1957).

Of the total food consumed by captive pikas during a 24-hour period, about 30 per cent was eaten during the day. There is a preference for half-dried vegetation, even during the summer when fresh plants and leaves are plentiful. As an example, a pika was observed feeding at Mt. Tomuraushi on 6 August 1956. The animal appeared from a crevice in the rocks and ran about 15 meters to a feeding area where it ate fresh plants for about 2 minutes. It then stuffed its mouth with plants or, holding the stems in its mouth, carried the food back to the crevice where it was deposited under an overhanging rock. This action was repeated eleven times, each trip taking about 70 seconds. The food was piled in a stack which was finally 15 cm. in diameter and 1 cm. high. This was not a true "haystack", however, as the food was gone three days later. This activity seems, instead, to be evidence of their preference for partially dried food. One also notices many small piles of dried plants more or less randomly distributed throughout pika habitats, and these too would seem to be evidence of the same activity.

TABLE 2.—*Identity of the plants stored by pika*

Thistle	*Cirsium* sp.
Greater plantain	*Plantago major*
Kaempfer's azalea	*Rhododendron obtusum*
Bunchberry	*Cornus canadensis*
Japanese hedge parsley	*Torilis anthriscus*
Japanese see cicely	*Osmorrhiza aristata*
Seven-lobed ginseng	*Kalopanax ricinifalius*
Silver vine	*Actinidia polygama*
Japanese linden (leaves)	*Tilia japonica*
Kalakogi maple (leaves)	*Acer ginnala*
Maple (leaves)	*Acer pictum*
Allegheny spruce	*Pachysandra terminalis*
Nepal cranesbill	*Geranium* sp.
False spiraea	*Sorboria sirbifula*
Goat's beard	*Aruncus sylvester*
Currant	*Ribes grossularoides*
Hydrangea vine	*Hydrangea petiolaris*
Bitter cress	*Dentaria macrophylla*
Bugbange	*Simisifiga yesoensis*
Alpine clematis	*Clematis alpina*
Alder	*Alnus maximowiczii*
Birch	*Betula* sp.
False lily-of-the-valley	*Maianthemum bifolium*
Wood fern	*Dryopteris dilatata*
Male fern	*Dryopteris crassirhizoma*
Siff club moss	*Lycopodium annotinum*
	Diclanum japonicum
Bush clover	*Lespedeza bicolor*

Pikas begin constructing true "haystacks" in October and continue this activity for a month or two, until snow starts falling. Fresh vegetation is always allowed to cure before more is added to the stack. Thus the stacks tend to spread out to about 1 meter in width when they are 60 cm. high. The amount of food in a single stack varies considerably. One unfinished stack in the spruce-fir forest of Rubeshibe weighed 3.5 kg. on 22 November 1956 and contained 2 kg. of wood fern, 600 grams of male fern, 450 grams of Allegheny spruce, 20 grams of bunch berry, 50 grams of small branches and 300 grams of unidentifiable material. It is thought that a pair of pikas cooperate in building the haystacks. If one pika is trapped near a haystack, fresh vegetation is often added to the stack subsequently, and two pikas can usually be trapped in the vicinity of one haystack.

Although pikas are mainly herbivorous, they are thought to eat small amounts of animal matter during the breeding season. They will eat mealworm larvae (*Tenebrio picipes*) in the laboratory, presumably because of a need for minerals and salts.

Pikas are coprophagous and have, as do rabbits and hares, two types of feces. Fresh fecal pellets are deep green and 3–4 mm. in diameter. The other type is blackish colored, soft, and about 3 mm. in diameter and 20–30 mm. long. The fresh pellets are defecated mostly during the daytime and the latter at night. The so-called "night feces" are encased in a gelatinous substance and are quite viscous, while the pellets voided during the day are harder and quite friable. Defecation at night usually takes place in a spot where there is good circulation of air and the pellets are left to dry until morning when they are eaten. According to Kulwich *et al.* (1953), coprophagy in the rabbit is due to a nutritional demand for vitamin B substances that have been formed in the caecum but have been voided without being absorbed. The same presumably applies to the pika, although pikas show considerable individual variation in this habit and further physiological and anatomical study is needed.

Home range.—Live-trapping was done with a box trap designed by T. Sakuma (See Fig. 1) and with standard mouse traps. The box trap is buried in the ground and bait is not necessary. Apple was used as bait for the standard mouse traps (Pruitt, 1954). A difficulty with the standard mouse trap is that the captured animals gnaw at the wire netting, damaging their teeth, and the traps are often preempted by field mice.

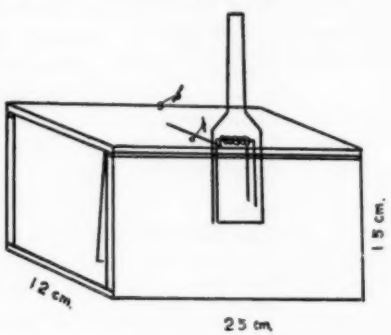


FIG. 1.—Box trap.

The studies of home range were made in the forest of Rubeshibe in the Kitami District. Pikas were trapped for three days, from 10 to 13 October

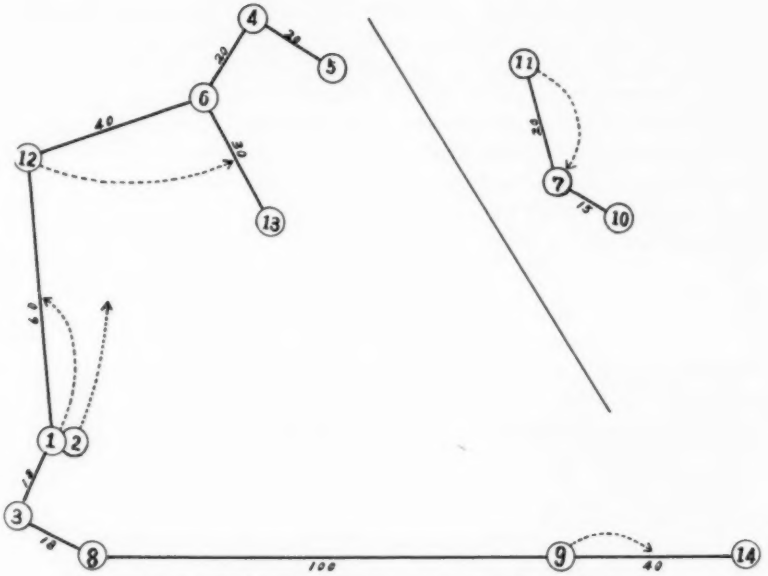


FIG. 2.—Cruising distance, in meters, of marked animals.

1956, and marked by the ear-punch method. These animals were released and retrapped from 22 November to 12 December 1956. A second retrapping was done from 25 May to 12 July 1957, and a third from 5 to 14 November 1957. The results are shown in Table 3 and Fig. 2.

The trapping area was approximately two hectares. The dominant vegetation was spruce and silver fir with a heavy undergrowth of mosses and plants listed in Table 2. The topsoil was relatively shallow, with an average depth of 30 cm., and was underlain with basalt. Pika haystacks are usually found at the roots of the fallen trees which are abundant in the area.

Table 3 and Fig. 2 summarize data on 14 pikas marked and released during the first trapping. Of this number, five were subsequently recaptured on the

TABLE 3.—*Trapping record of marked and released pikas*

DATE	NUMBER OF ANIMALS		DISTANCE MOVED SINCE LAST CAPTURED (METERS)
	Unmarked	marked	
10–13 October 1956	0	14	
22 Nov. to 2 Dec. 1956	15	2	30, 30
22 May to 12 July 1957	17	2	26, 40
5–14 Dec. 1957	11	1	20
Total	43	5	

dates shown. The calculated distances moved between marking and recapture were 20 to 40 meters, and the home range is estimated to average 30 meters in diameter. These results are similar to those reported by Hall (1946:49) for *Ochotona princeps*.

Since 43 unmarked pikas were captured in the same area during the recapture periods, it is presumed that home ranges overlap considerably but that the animals remain within a home range. Kilham (1958) has reported on the territorial behavior of pikas, but the data in the present paper are too few to allow comparisons or further conclusions.

Reproduction.—The breeding season of the Japanese pika is assumed to be from May to July. Pregnant females near parturition were captured on 3, 20

PLATE I

UPPER: Adult pika, study skin. LOWER LEFT: Mother pika and 8-day-old baby. LOWER RIGHT, *left to right*: Young pikas immediately after birth and at 6 and 8 days of age.

and 25 June and on 2 July 1957. Three of these females carried two embryos and one had three. Two of the females gave birth prematurely and the young died. Absorption was observed in one female. The fourth female gave birth to a litter of three young, of which one died at birth, one lived 6 days and the third lived 8 days. Body measurements and weights of each of the young at the time it died are shown in Table 4. The skins and skulls are shown in Plate I. According to Severaid (1950), the gestation period for *Ochotona princeps* is 30½ days, but data are not available for the Japanese pika.

Growth and development.—Newborn pikas are lightly furred with darkish brown dorsal pelage and the abdomen covered with soft, white fur. The eyes and ears are closed, the upper and lower incisors are slightly erupted, and pairs of mammae are barely visible on the breast and abdomen. By the sixth day the dorsal pelage becomes grayish brown, the upper incisor is 0.5 mm. long and the lower incisor 1.0 mm. long, and the molars have not erupted but are visible. The toe nails have darkened by the sixth day and the mammae are clearly visible. By the eighth day the young pika is able to move unsteadily and can stand upright. It begins to utter a call which sounds like *chii, chii.* The eyes are still closed on the eighth day, the upper incisor is 1.5 mm. long, the lower incisor is 2.5 mm. long, and the molars have erupted. Since none of the young born in captivity lived past the eighth day, no further data on development were obtained.

Weights of captive pikas are shown in Fig. 3. Two young pikas (No. 1 and 2) showed remarkable increases in weight. Number 1 weighed 60 grams when it was captured on 12 July and weighed 120 grams by 9 August. This constitutes a daily gain of 2.2 grams. Number 2 showed a weight increase of 1.7 grams per day. Pika No. 1 was estimated to be 20 days old when it was captured (60 grams). One animal which weighed 40 grams when it was captured was estimated, from its pelage and stage of development, to be 15 days old. The adult body weight is assumed to be about 120 grams.

The weights of the three pikas born in captivity and those of No. 1 and 2 mentioned above are shown on the left side of the graph in Fig. 3. The combined coefficient of growth of the pika, calculated from these values, is compared in Fig. 4 with those for the brown lemming and tundra red-backed vole (Morrison *et al.*, 1954). Coefficient of growth was calculated as $k = 100 (m_1 - m)m$. The pika shows the highest coefficient of growth, with the vole

TABLE 4.—*Weights and measurements of young pikas*

	AGE, DAYS		
	1	6	8
Body weight, gm.	9.6	15.0	19.0
Body length, mm.	60.0	72.0	83.5
Hind foot s. u., mm.	11.0	13.0	16.0
Tragus, mm.	5.0	5.0	6.0

second and the lemming last. In the lemming and tundra vole a physiological decrease in body weight occurs at about eight days after birth. This event is estimated to occur about the sixth day after birth in the pika.

Disease.—Compared with other laboratory animals, pikas seem to have a low resistance and are highly susceptible to disease. Many died during the

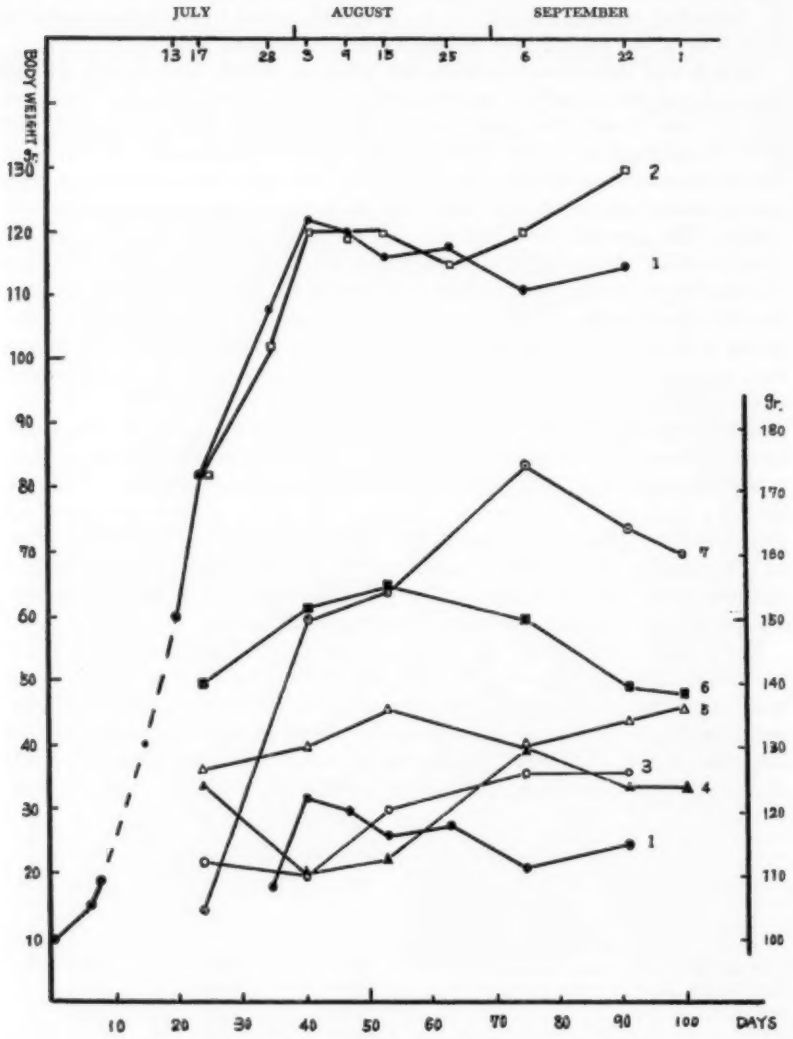


FIG. 3.—Growth curves (body weight in grams) of pikas.

early part of this study because of dietary deficiencies, respiratory disturbances, digestive disturbances, ectoparasite infestations, and septicemia through injuries sustained from fighting. Excessive abrasion of the incisors often led to a decrease in appetite and, conversely, lack of abrasion and excessive incisor growth prevented some animals from feeding. Following are accounts of some of these incidents:

Pneumonia: Animals showed a thick mucous discharge from the nostrils and a nasal catarrh symptomatic of pneumonia. These symptoms were followed by loss of appetite. The animals crouched in a corner and died within three or four days.

Aspergillosis: Symptoms similar to those shown by aspergillosis in the emperor penquin (*Aptenodytes excelsior*) were observed. There was difficulty in breathing, loss of appetite and diarrhea. This seems to be the most fatal disease of animals of the alpine region. Spraying with a dilute solution of crystalline aureothrycin and alcohol (Koga *et al.*, 1955) alleviated the pre-

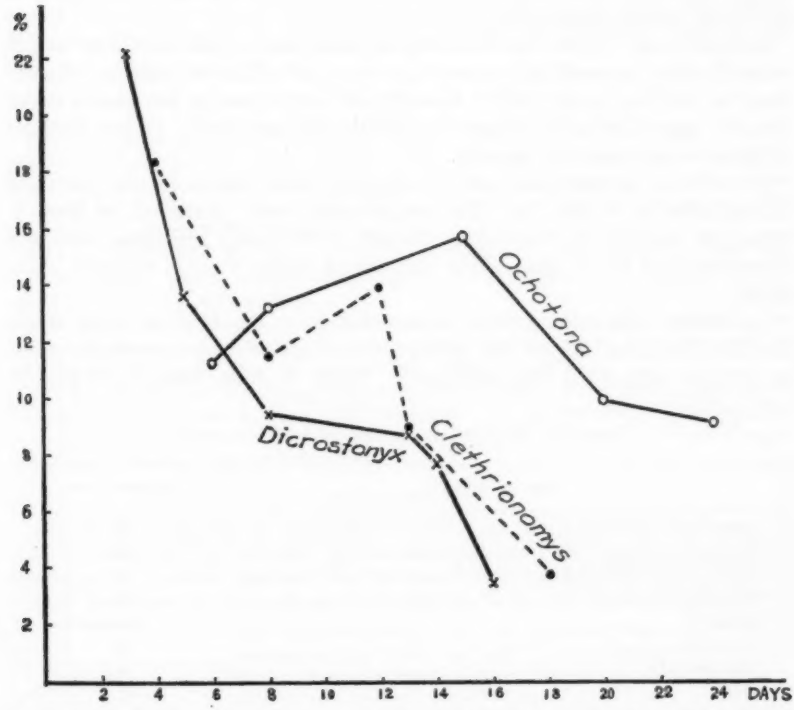


FIG. 4.—Comparison of growth curves (body weight) of pika and other rodents of cold regions.

valence of this disease. The spray was directed toward nostrils of the caged pikas at a dose of about 5 cc. of spray per pika.

Dietary deficiency: Dietary deficiencies were mainly due to lack of vitamins A and D and minerals. The entire face of the animal began to swell, the eyes became sunken or were stuck shut, the pelage became fluffy, and there was a gradual loss of appetite. Minex (mineral) and Albita (vitamin A and D) restored animals to normal with fair success. Since bush clover contains vitamin B and pikas are coprophagous, this vitamin was not administered in any special form.

Incisor growth: Extreme abrasion of the incisors and subsequent loss of appetite was caused by the animals gnawing the wire mesh of their cages. This was stopped by moving them into wooden cages. Extreme lengthening of the incisors was prevented by feeding branches of bush clover and false acacia and, sometimes, cutting the ends of the incisor with nail clippers.

Fighting: Injuries from fighting were caused less by biting than by striking with the front paw and hooking the nail into the back and pulling toward the rump. Bleeding and septicemia often followed. It was found necessary to house the animals separately.

Ectoparasites: Larvae of *Cuterebra reporina* were found on about one of every 20 pikas captured and seemed to be the pika's main ectoparasite. Larvae from the size of a poppy seed to that of a pea were found in the muscle under the skin, especially in the region between the hip and thigh. In one instance 30 larvae were found on one pika.

Trombicula pomeranzevi and *T. microti* were found in the ear and *Ctenopsyllus* sp. in the fur. The ectoparasites were identified by Prof. J. Yamashita, Institute of Parasitology, Faculty of Veterinary Medicine, Hokkaido University, and Dr. Z. Ono of the Institute of Public Health, Sapporo, Hokkaido.

Laboratory care.—Pikas were transported from the field in cages made from 5-gallon cans. Those that suffered from heat exhaustion were placed in an outdoor cage until they recovered. Three to four stones 5–10 cm. in

TABLE 5.—*Food ration (per day) of laboratory pikas*

KIND OF FOOD	QUANTITY, GM.
Apple	60
Bush clover, fresh	20
Bush clover, half-dried	6
Wheatgerm powder	14
Mineral	tr.
Calcium	tr.
Vitamin A.D.	tr.
Salt	tr.
Honey	tr.
Water	about 14 cc.

diameter were placed in the cage, along with a block of ice. Healthy pikas were normally kept in standard laboratory cages.

The daily food ration is shown in Table 5. Apple was washed and quartered and given with the rind intact. Fresh bush clover was also washed. Partially dried bush clover was prepared by allowing the fresh leaves to dry in the shade until the moisture content was 10 to 15 per cent. Wheat germ powder, minerals, vitamins A and D, salts and calcium were mixed with honey and water to form a paste. Water was provided *ad libitum*.

At the beginning of the study the mortality rate of captive pikas was quite high. When apples and bush clover leaves were provided, mortality decreased considerably. As mentioned previously, it was also found that the need for minerals and vitamins is high. Pikas also showed a liking for false acacia leaves (*Robinia pseudoacacia*), red clover and lettuce. Pikas vary individually in their taste for mealworm larvae.

The room in which the pikas were kept had no special means of ventilation and temperatures ranged from 20 to 30°C. Since these temperatures are far above the presumed optimum for pikas (12 to 14°C.), blocks of ice were placed in the cages once or twice a day. When the room temperature was above 25°C., the animals sat close to the ice, often with their bodies touching it, and frequently licked the ice block.

SUMMARY

The distribution of the Japanese pika is limited to Mt. Taisetsu, the central mountain range of Hokkaido and part of the Hidaka range. The limiting factor in habitat distribution seems to be terrain, rather than altitude, temperature, or food species. Pikas do not hibernate and are active on top of the snow until it reaches a depth of 20–30 cm., after which they are active in tunnels under the snow.

Pikas are herbivorous and eat most of the plant species in their habitat. They store food in autumn. During summer they eat fresh plants, but also cure vegetation in haystacks for summer consumption.

Pikas are coprophagous. They produce two types of fecal pellet. The fecal pellet defecated during the night is elongated and viscous and is deposited in a site with good air circulation. The night pellets are reingested the following morning.

The breeding season is assumed to be from May to July. The observed litter size in trapped animals was two to three. An account of early development of newborn pikas is given.

Laboratory feeding, care and disease are described.

ACKNOWLEDGMENTS

I would like to express my appreciation to Prof. T. Inukai of Hokkaido University and Prof. Y. Tajima of Tokyo University for suggestions during this study. I would also like to thank Mrs. Masu Nomura and Miss Michi Nomura for their help in keeping pikas, and Mr. T. Sakuma for helping in their capture. I am grateful to Dr. Richard S. Miller for editing the manuscript.

LITERATURE CITED

ANTHONY, H. E. 1928. Field Book of North American Mammals. G. P. Putnam's Sons, New York. 674 pp.

BAILEY, V. 1931. Mammals of New Mexico. N. Amer. Fauna 53: 66–67.
DIXON, J. 1931. Pikas versus weasel. Jour. Mamm., 12: 72.
HAGA, R. 1957. Ecological studies and damage done by pikas in afforestation. Japan Northern Forestry, No. 104: 1–3.
HALL, E. R. 1946. Mammals of Nevada. Univ. Calif. Press, Berkeley. 710 pp.
HAMILTON, W. J. 1939. American Mammals. McGraw-Hill Book Co., New York. 434 pp.
HAYWARD, C. L. 1952. Alpine biotic communities of the Uinta Mountains, Utah. Ecol. Monogr., 22: 93–102.
INUKAI, T. 1931*a*. A food hoard of *Ochotona* from Taisetsu zan, the Central mountains of Hokkaido. Trans. Sapporo Nat. Hist. Soc., 11: 210–214.
———. 1931*b*. A record of *Ochotona* from Sakhalien. Trans. Sapporo Nat. Hist. Soc., 12: 6–8.
———. 1932. Distribution of *Ochotona* so far discovered in Hokkaido and Sakhalien. Proc. Imper. Acad., 8: 255–258.
——— AND K. SHIMAKURA. 1930. On *Ochotona*, a new rodent unrecorded from Hokkaido. Trans. Sapporo Nat. Hist. Soc., 11: 115–118.
KILHAM, L. 1958. Territorial behavior in pikas. Jour. Mamm., 39: 307.
KISHIDA, K. 1933. General remarks on *Ochotona*. Jap. Plants and Animals, 1: 21–34.
KOGA, T., N. FUKUDA, S. ASAKURA AND S. NAKAGAWA. 1955. On aspergillosis of penguins in Ueno Zoological Garden., Tokyo.
KULWICH, R., L. STRUGILIA AND P. B. PEARSON. 1953. The effect of coprophagy on the excretion of B vitamins by the rabbit. Jour. Nutrit., 49: 639–645.
LOUKASHKIN, S. A. 1940. On the pikas of north Manchuria. Jour. Mamm., 21: 402–405.
MORRISON, P. R., F. A. RYSER AND R. L. STRECKER. 1954. Growth and development of temperature regulation in the tundra redback vole. Jour. Mamm., 35: 376–386.
PRUITT, W. O. 1954. Notes on Colorado Phenacomys and pikas. Jour. Mamm., 35: 450–452.
SAKAGAMI, S. F., H. MORI AND H. KIKUCHI. 1956. Miscellaneous observations on pika, *Ochotona* sp., living near lake Shikaribetsu, Taisetsu zan National Park, Hokkaido, Japan. Jap. Jour. App. Zool., 21: 1–9.
SEVERAID, J. H. 1950. The gestation period in the pika (*Ochotona princeps*). Jour. Mamm., 31: 356–357.
TATE, G. H. H. 1947. Mammals of Eastern Asia. Macmillan, New York. 366 pp.
TOMODA, Y. 1956. Damage done by the rare animal, pika. Shinrin Boeki News, No. 5: 33–35.

Zoological Institute, Faculty of Agriculture, Hokkaido Univ., Hokkaido, Japan. Received 19 November 1958.

AIBS MEETING

Any members attending the AIBS Meeting at Stillwater, Oklahoma, 28 August to 1 September, are cordially invited to visit the Society's office. After the meeting Dr. Glass intends to conduct a field trip to observe the *Tadarida* flight, which is at its best at this season.

AN APOCRINE GLAND COMPLEX OF THE PIKA

By Elmer B. Harvey and Lauren E. Rosenberg

The occurrence and morphology of regular and apocrine sweat glands are well documented for man (Bunting *et al.*, 1948); for other species the picture is less complete. Schaffer (1940) reviews extensively skin glands of mammals, especially their histological formation. Descriptions of three apocrine glands of caribou are discussed by Quay (1955). Dalquest and Werner (1954) found that the face skin of seven families of bats contains extensive glandular areas (probably of apocrine nature). Lateral and ventral scent glands of the short-tailed shrew were described by Coues (1896), Eadie (1938) and Pearson (1946). Epling (1956) describes a dorso-lumbar scent gland of the javelina. Scent glands and other skin glands of apocrine nature are similar in histologic features in the mammals described to date. Montagna (1950) described merocrine secreting inguinal glands which are responsible for the characteristic odor in rabbits.

This paper reports a skin gland of a lagomorph, *Ochotona princeps*, which is unique in having the coiled tubules of the apocrine portion embedded in a highly basophilic cell mass variable in size in different reproductive states of the animal.

MATERIALS AND METHODS

Pikas were collected from Bodie, Mono County, California, during May 1953, 1954, 1955, and July 1955. Immediately after killing, the reproductive structures and an area of skin about 1.5 cm. square below the base of the ear were excised and fixed in Bouin's fluid. Reproductive structures were sectioned and examined to determine the reproductive state of the pika. The cheek skin with its apocrine gland was embedded in paraffin, sectioned at 7–10 μ and stained either with Harris' hematoxylin and eosin, Foot-Menard followed by Heidenhain's azan, Bodian's protargol stain, or orcein elastic tissue stain. A few of the glands on the opposite side were embedded in gelatin, sectioned with a freezing microtome and stained with Sudan III.

Glands were collected from adult males with active and inactive testes, and from one juvenile male; and from adult females which were pregnant, non-pregnant lactating and non-lactating.

DESCRIPTION OF THE GLAND

Pelage hairs of the pika are mostly white, yellow or brown at their tips and with black shafts which extend into the hair follicles. In a small area about 5 mm. ventro-caudad to the base of the ear, the hairs are yellow-brown throughout their length. In the center of this region an area about 5 mm. square has hairs that are broken and short (to 5 mm. in length) and more dense than in other regions of the body. These hairs overlie the secretory area of the apocrine gland. Two main ducts discharge separately at pores in two small highly pigmented papillae, which extend slightly higher than the surrounding skin.

Overlying the gland area the skin has more folds than that of the body, which is relatively smooth.

Epidermis.—On the body of the pika the epidermis has three distinct layers (Plate I, 1). The deepest layer, stratum germinativum, is without a well-defined basement membrane; its two divisions, the stratum cylindricum and stratum spinosum, are each composed of a single layer of cells. Nuclei and discrete cells are few in the stratum granulosum, and the stratum corneum desquamates extensively. The three layers total about 14 μ thick. A few scattered melanophores are present. Around the hair follicles pigment cells are more numerous (Fig. 1).

The area of epidermis onto which the apocrine gland secretes is about 35 μ thick. Here the cells of the stratum cylindricum are low columnar and the stratum spinosum is 2–3 cells thick. The stratum granulosum has discrete nuclei and occasionally cell limits are distinguishable. Numerous melanophores occur in the epidermis of this region (Plate I, 2).

The epidermis is thickest (45 μ), most heavily pigmented, and composed of the greatest number of cell layers (4–5) just around the duct opening.

Apocrine gland.—The apocrine glands are extensively branched, coiled epithelial tubes. The secretory portion is an irregular tight coil lying deep in the derma; unlike other apocrine sweat glands described in the literature, it is embedded in a basophilic cell mass ("B gland") to be described later (Plate II, 7–10).

The secretory epithelium and most of the duct have a well-defined basement membrane within which are many myoepithelial cells.

In the terminal portion of the gland, epithelial cells vary in shape, apparently with the secretory activity of that particular region of the gland. They range from squamous to low columnar (Figs. 4–6, 10). In the pika it appears that this gland may secrete by holocrine (Fig. 10) or apocrine (Figs. 4, 5) methods; perhaps some merocrine activity also occurs (Fig. 12).

In glands stained by Sudan III, fat was most evident in the lumen of the apocrine area and less evident in the epithelial cells of the "B" mass (Figs. 7, 8). Tissue stained with Foot-Menard reticular stain or by the Bodian nerve stain shows dense argyrophylic granules at the apex of the secretory cells. Some

---

1. Skin showing secretory duct opening and large sebaceous glands opening into the duct of the apocrine gland (female, early pregnancy). H & E × 250.
2. Secretory duct showing stratified epithelium, melanophore concentration in stratum germinativum, and discrete cells of stratum granulosum and stratum corneum (female, estrous). H & E × 500.
3. Secretory duct epithelium deeper than shown in Fig. 2. H & E × 1000.
4. Terminal portion of an apocrine gland tubule illustrating types of secretion, and cell types in the epithelium (female, estrous). H & E × 1000.
5. Terminal apocrine gland tubule (*A*) illustrating epithelium, myoepithelial cell (*M*) and the "B gland" (female, estrous). H & E × 1350.
6. Apocrine gland epithelium illustrating myoepithelium (*M*) and basement membrane (*BM*) (female, estrous). H & E × 1350.

silver-staining blebs of protoplasmic material are found in the lumina (Figs. 11, 12). Extensive mitotic activity in the secretory portion was noted in only one specimen, a female with a pro-nucleus stage pregnancy.

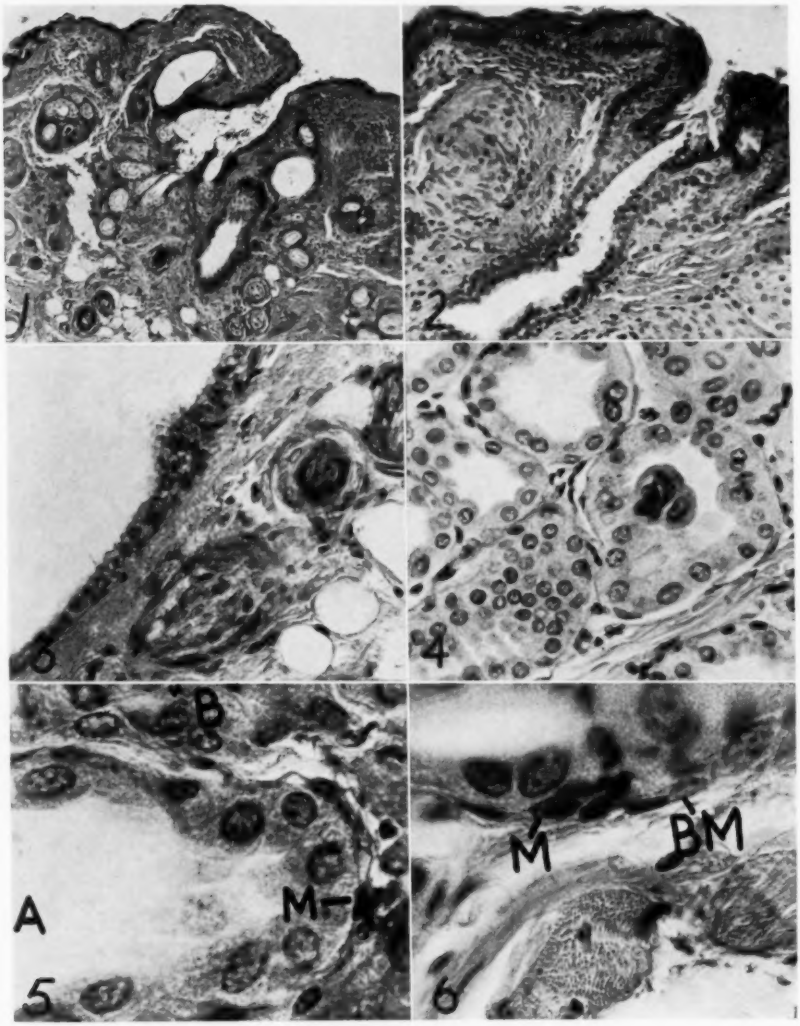


PLATE I

Sections through cheek glands of pika. Legends opposite.

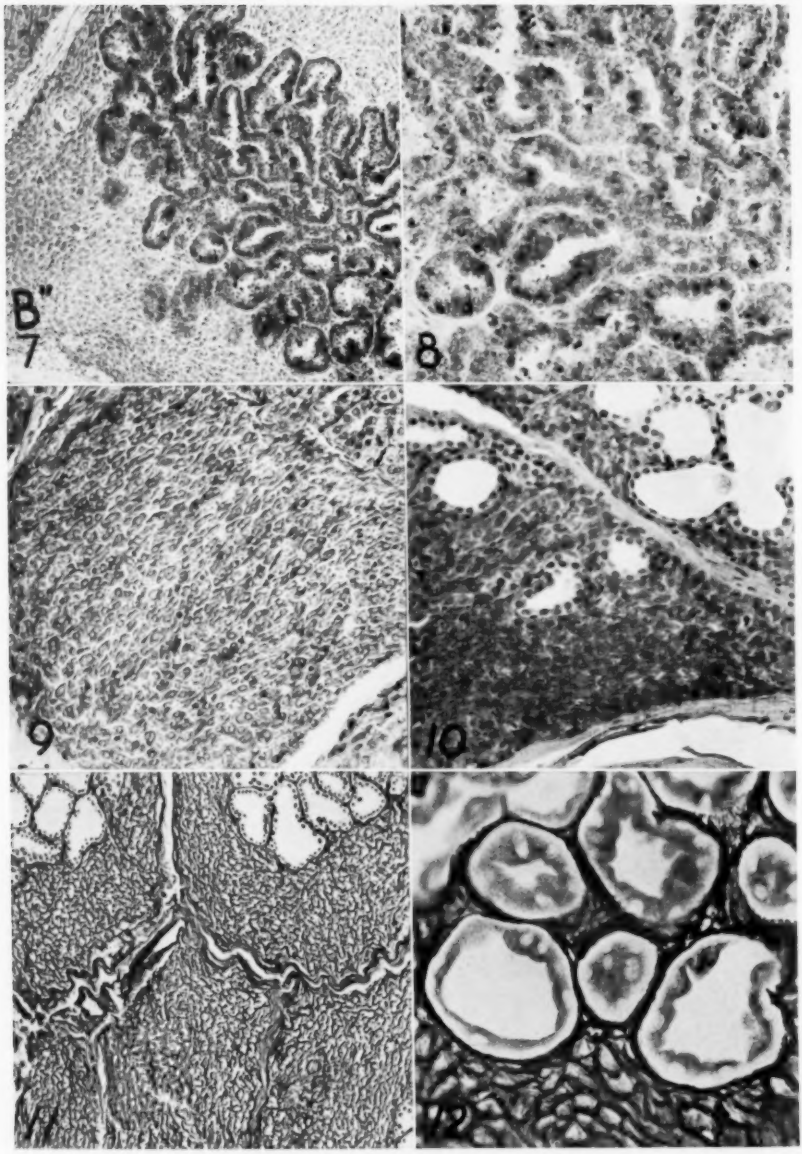


PLATE II

Sections through cheek glands of pika. Legends opposite.

Ducts leading from the terminal portions of the gland meet in the derma. The duct epithelium near the secretory portion is simple and squamous but becomes cuboid (Fig. 3) and finally stratified columnar as it nears the skin (Figs. 2, 3). It also appears that the epithelial cells of the duct contribute to the secretory material in the lumina by apocrine secretion.

About 180 μ from the surface of the skin, the epithelium of the duct begins to approximate that of the epidermis. It is here that sebaceous glands (larger than those at the base of the hairs) open into the apocrine duct (Fig. 1) and the basement membrane becomes difficult to identify. An occasional melanophore is found in the stratum germinativum. Nearer the epidermis, melanophores increase in number and the stratum granulosum shows discrete cells and nuclei which make up a considerable part of the desquamate from the stratum corneum in this region (Fig. 2).

"B GLAND"

Surrounding each coiled terminal segment of the apocrine gland is a "mass" of cells which we have called the "B gland" for descriptive purposes. The total "B gland" mass lies deep in the dermis and subcutaneous tissue. It extends craniocaudad and dorso-ventrad for distances of 4–9 mm. and has a thickness of 1–3 mm. It is composed of up to 35 lobules separated more or less completely by septa composed of collagenous, reticular and some elastic connective tissue (Figs. 7, 10, 11).

Cells of the "B gland" are irregular in shape but tend to be elongate. They may be uni- or binucleate cells. The nuclei are spherical with two well-defined nucleoli. Cytoplasm of these cells is highly basophilic.

The "B" cells are in columns (Fig. 9). Each column is separated by a thin layer of collagenous and reticular connective tissue (Figs. 9, 11, 12) continuous with that of the interlobular septa. Elastic tissue is not seen between "B gland" cells.

DISCUSSION

A number of functions have been ascribed to apocrine sweat glands in various orders. In man and other species, including the pika, eccrine sweat glands lie

---

7. Terminal apocrine gland tubule coiled in the "B gland" lobule (*"B"*) (male, active testes). Sudanophilic material in the lumen and epithelium is the darker material in photo. H and Sudan III. × 250.

8. Same slide as illustrated in Fig. 7. × 500.

9. Section illustrating alignment of "B gland" cells into columns (male, active testes). H & E × 500.

10. Section illustrating the intense basophilia of the "B gland" cells (male, active testes). H & E × 500.

11. Section through "B gland" lobules illustrating the extensiveness of reticular tissue in this structure (male, active testes). Protargol × 250.

12. Section of the apocrine and "B gland" illustrating extensiveness of reticular tissue and argyrophilic granules of the epithelium. (Same tissue as in Fig. 11). Foot-Menard. × 1000.

within the derma while apocrine sweat glands are larger and extend more deeply into the derma. The latter are usually restricted to specialized areas in man: axilla, nipple, midline of the abdomen, pubic, peri- and circumanal regions as well as the labia majora (Bunting *et al.*, 1948). Glands of Moll and ceruminous glands of the auditory canal are of this type.

Embryologically, apocrine glands develop in conjunction with hair follicles and reach full maturity at puberty, thus acting as secondary sex characteristics. A correlation exists between the secretory activity of apocrine glands and phases of the menstrual cycle, according to Loeschke (1925); however, this has been denied by Klaar (1926).

Caribou and other artiodactyls have apocrine sweat glands in the tarsal, interdigital and preorbital regions. According to Quay (1955) the extent of these glands varies in the male and female, apparently being more extensive in the latter. No evidence has clearly indicated a function for these glands in artiodactyls.

Epling (1956) describes a dorso-lumbar apocrine scent gland in the javelina to which a number of functions have been assigned: identification of the mother by the young, danger scent to other peccaries (Cahalane, 1947), trail marker and mosquito repellent. These functions are without experimental proof.

Short-tailed shrews have three gland areas of apocrine nature on the skin, one on each flank and one in the ventral mid-line. Both of these produce a scent characteristic of the shrew (Pearson, 1946). Although other functions have been ascribed to these glands, Pearson believes they serve to mark the network of tunnels in which they live, thereby establishing a territory. Scent glands of estrous females are reduced, thus an unscented tunnel encourages entrance by a wandering male.

Rabbits have a characteristic odor which, according to Montagna (1950), is derived from inguinal glands that are branched tubular, merocrine glands. These in rabbits are not altered by castration or reproductive activity. A similar gland has not been reported in pikas.

The apocrine sweat gland on the cheek of pikas does not differ histologically from this type of gland described for other mammals. It is unique, however, in that the terminal portions of the apocrine tubules are coiled in a mass of basophilic cells ("B gland") not previously described in other mammals. The "B gland" is more basophilic and extensive in estrous females and in those males with reproducitvely active testes than in the pregnant females and juvenile males or males with testes that are not actively producing sperm. Since the "B gland" mass is not highly vascular, it is doubtful that it is an endocrine gland. It may contribute in some way to the apocrine secretion and thus serve a behavioral function. We were unable to detect an odor emanating from the gland.

Pikas, unlike rabbits and hares, inhabit spaces and holes between rocks of talus; thus a well-developed apocrine gland as described may serve an adaptive

function for the habitat in which pikas live. They have been observed rubbing their cheeks with their fore paws and scratching this area with hind paws. Kilham (1958) observed pikas rubbing both cheeks against rocks as they ran about their "territories." These behavior patterns may account for the broken and short hairs in the central area of the gland. Washing and scratching may bring the apocrine secretion on to the feet, thus marking their quarters, as in the case of shrews brushing the walls of their burrows (Pearson, 1946).

Severaid (personal communication, 1953) observed mating pikas sniffing at each others' cheeks. This suggests a hedonic function of the apocrine glands.

Pikas may, during the breeding season, establish rather definite territories which are less strictly adhered to during diestrus. Unlike the shrew's "scent" gland, the apocrine gland of the pika may serve to invite the attentions of wandering males.

SUMMARY

There is in the posterior cheek region of pikas (*Ochontona princeps*) an apocrine gland which is unique in that its tubules are coiled in an organized mass of basophilic cells ("B gland"). To our knowledge this complex has not been reported previously for any other mammal.

Morphological and histological features of the apocrine sweat gland of pikas do not differ from this type in other mammals.

The size of the cheek gland varies with the reproductive activity of the pika. It would seem that this gland may be of some advantage to pikas in their specialized habitat.

LITERATURE CITED

Bunting, H., G. B. Wislocki and E. W. Dempsey. 1948. The chemical histology of human eccrine and apocrine sweat glands. Anat, Rec., 100: 61–77.

Cahalane, V. H. 1947. Mammals of North America. Macmillan Co., N. Y. 682 pp.

Coues, E. 1896. Three subcutaneous glandular areas of *Blarina brevicauda*. Science, 3 (73): 799.

Dalquest, W. W. and H. J. Werner. 1954. Histological aspects of the faces of North American bats. Jour. Mamm., 35: 147–160.

Eadie, W. R. 1938. The dermal glands of shrews. Jour. Mamm., 19: 171–174.

Epling, G. P. 1956. Morphology of the scent gland of the javelina. Jour. Mamm., 37: 246–248.

Kilham, L. 1958. Territorial behavior in pikas. Jour. Mamm., 39: 307.

Klarr, J. 1926. Zur Kenntnis des Weiblichen Axillarorgans beim Menschens. Wien Klin. Wchr., 39: 127–131.

Loeschke, H. 1925. Uber zychlische Vorgänge in den Drüsen des Achselhöhlenorgans und Ihre Abhängigkeit vom Sexualzyklus des Weibes. Virchows Arch. f. path. Anat., 255: 283–294.

Montagna, W. 1950. The brown inguinal glands of the rabbit. Amer. Jour. Anat., 87: 213–238.

Pearson, O. P. 1946. Scent glands of the short-tailed shrew. Anat. Rec., 94: 615–626.

Quay, W. B. 1955. Histology and cytochemistry of skin gland areas in the caribou, *Rangifer*. Jour. Mamm., 36: 187–201.

Schaffer, J. 1940. Die Hautdrusenorgane der Saugetiere mit besonderer Berucksichtigung ihres histologischen Aufbaues und Bemerkungen uber die Proktodaaldrusen. Urban und Schwarzenberg, Berlin and Wien. 464 pages.

Montana State College, Bozeman, and Univ. of California, Davis. Received 2 February 1959.

POLYMORPHISMS IN POPULATIONS OF WILD HOUSE MICE

By L. C. Dunn, Andrew B. Beasley and Harriet Tinker

Many of the populations of *Mus musculus* found in different parts of North America are polymorphic for genes affecting easily observable external characters. The polymorphism to which chief attention has been given involves the occurrence in the same population of two genotypes, one homozygous for the normal alleles at a locus *T* concerned with the development of the tail and other axial structures, the other heterozygous for a recessive variant allele at this locus (+/*t*). Of 16 such *t*-alleles studied in the laboratory, each derived from a single heterozygote trapped in the wild, thirteen are lethal before birth when homozygous while three form viable homozygotes of which the males are always sterile (Dunn, 1957*a*). All such alleles detected in wild populations are therefore subject to strong negative selection and we should expect to find them only in some low frequency comparable to the square root of the rate at which new mutations to *t*-alleles occur.

In fact they are not rare and have been found in most American populations of which adequate samples have been tested. The main evolutionary problem concerning the alleles at this locus is how such a polymorphism may be maintained in nature. The first factor found to contribute to the maintenance of the polymorphism is the peculiar way in which male heterozygotes transmit the variant alleles to their progeny. Instead of transmission of the allele to half the offspring, as occurs normally with alleles at other loci and in females +/*t*, males with an allele derived from a wild population regularly transmit the variant allele to from 90 to 99 per cent of their offspring. It has been shown (Dunn, 1957*a*; Bruck, 1957) that, assuming equality of other factors influencing the frequency of the + and *t* alleles, a lethal allele which is favored by such a transmission advantage should attain very high equilibrium values in any population in which it occurs. The equilibrium frequency expected for a lethal allele with a male transmission ratio of .96 (the average for all alleles derived from wild populations) should be near .5, that is, most of the individuals in a population in which such a lethal occurs should be heterozygous for it. This was so at variance with common sense considerations that agencies acting in the opposite direction, namely to reduce the frequency of lethal alleles, were sought. The first to be tested, relative fitness of heterozygotes +/*t* and normals +/+, turned out to act in the *same* direction as the transmission ratio, to favor the heterozygotes, and thus to increase further the frequency of the lethal alleles. This would lead to very high equilibrium values of such alleles in wild populations in which they are present. Furthermore, if a population polymorphic for such an allele is in reproductive communication with other populations, the allele might be expected to establish itself over a wider territory.

We propose now to test the above expectations by comparing the results obtained from testing samples of wild house mice collected in different parts

of the United States. The same collections made for this purpose gave us incidental observations on several other variant phenotypes which are frequent in wild populations, and indicate that such populations are polymorphic in several ways.

METHODS

Wild mice are trapped as described previously (Dunn and Suckling, 1956). Early collections were made in farm buildings, houses and a few city apartments; later such locations were avoided and collections taken only from free-living populations. Populations from both types of habitat yielded *t*-alleles and variants of other types. All mice brought to the laboratory are individually identified by ear marks.

WILD × SHORT-TAILED (BRACHY) FROM DOMESTIC STOCK *T*/+

F_1 = ½ normal tail, ½ short-tail. Diagnosis: wild is +/+.

F_1 = ½ normal tail, ¼ short-tail, ¼ tailless

F_1 tailless (*T*/*t*) × F_1 tailless (*T*/*t*)

T/*T*	*T*/*t*	t^1t^1	t^vt^v
lethal	tailless	lethal	normal

Diagnosis: Wild is +/*t*; t^1t^1 lethal before birth or t^vt^v viable.

FIG. 1.—Method of testing wild house mice for presence of a *t*-allele.

Tests for the presence of *t*-alleles are carried out in the laboratory by mating wild-caught animals individually with mice from a laboratory stock heterozygous for a dominant marker gene *T* at this locus. Such heterozygotes (*T*/+) have short blunt tails, about three-fourths of the normal length. Mating of these with an animal of genotype +/*t* produces young of three phenotypes sharply distinguishable at birth: those with normal tails (+/+, +/*t*), short ("Brachy") tails (*T*/+), and completely tailless ones (*T*/*t*). Proof that the wild population contains +/*t* animals is completed only after balanced tailless lines are derived from such heterozygotes. Matings between tailless offspring from a single heterozygote +/*t* produce only tailless offspring (*T*/*t*) if the *t*-allele is lethal, or tailless and normal offspring (*tt*) if the *t*-allele is viable. All alleles so derived are maintained in inbred balanced stocks in the laboratory. Matings of *T*/+ by +/+ animals produce normal and Brachy progeny, but also rarely a tailless offspring which when tested proves to be *T*/+, probably with modifying genes for short tails derived from the wild parent (see Table 2 and Fig. 1).

RESULTS

All wild mice observed had tails of normal length. Most populations were found to consist of mice of two genotypes, +/+ and +/*t*, which were not

phenotypically distinguishable. The *t*-alleles derived from different wild heterozygotes are designated t^w, with a number identifying the source.

The results of testing in this way samples of mice from different sources are summarized in Tables 1 and 2. Table 1 shows the results of tests of samples from those trapping sites which yielded at least one heterozygote. It is obvious from the table that from all populations except one only small numbers of animals were tested. This is in part due to the sterility of many wild mice when brought into the laboratory. In our experience, only about one-third of the females captured have produced litters in the laboratory. The proportions of males which bred was much higher.

The source of population 1 differed from that of the others. This population was derived from a small number of wild mice trapped in New York City and Philadelphia, Pennsylvania, and had been maintained in captivity in the laboratory of Dr. Howard Schneider of the Rockefeller Institute for Medical Research. At the time when we sampled this population it had been breeding in captivity for about ten years. The rather large sample which we tested consisted of over 50 per cent heterozygotes, and two different *t*-alleles were present. One, t^{w1}, is a lethal; the other, t^{w2}, is viable when homozygous. All males of genotype t^{w2}/t^{w2} were completely sterile. This is the only sample of a large population in which we were able to get a reliable gene frequency.

TABLE 1.—*Locations (trapping sites) at which at least one heterozygote ($+/t^w$) was detected and the allele isolated in a balanced line (T/t^w)*

POPULATION	LOCATION	TESTED	$+/t^w$	ALLELE ISOLATED	LETHAL OR VIABLE	ALLELE ASSIGNED BY TEST TO GROUP
New York 1	*	71	52	t^{w1}	lethal	2
				t^{w2}	viable	1
Connecticut 1	Mystic	3	1	t^{w3}	lethal	2
Wisconsin 3	Madison†	6	1	t^{w4}	lethal	t^0
New York 2	70 W 106 St.	2	1	t^{w5}	lethal	3
Florida	Sarasota	4	1	t^{w6}	lethal	3
Texas 1	near Austin	10	3	t^{w7}	viable	1
Virginia	Rumford	11	2	t^{w8}	viable	1
New York 3	Tiemann Pl.	1	1	t^{w9}	lethal	?
Montana	Clark Fork River	2	1	t^{w10}	lethal	3
Connecticut 2	Storrs	7	5	t^{w11}	lethal	3
California	Corte Madera	1	1	t^{w12}	lethal	2
Texas 2	El Paso	3	3	t^{w13}	lethal	3
Vermont 1a‡	Norwich, W.	8	1	t^{w14}	lethal	3
Kansas	near Lawrence	6	1	t^{w15}	lethal	3
Vermont 1b‡	Norwich, W.	1	1	t^{w16}	lethal	3
Arizona	near Tucson	4	1	t^{w17}	lethal	3

* This population had been bred in captivity from wild mice trapped in New York City and Philadelphia, Pa.
† From a confined population descended from wild ancestors.
‡ From different buildings on the same farm.

TABLE 2.—*Locations (trapping sites) at which no heterozygotes (+/t^w) were detected*

LOCATION	NUMBER OF ANIMALS TESTED BY $T/+$		RESULTS OF TEST CROSSES		
	♀	♂	normal	Brachy	tailless
Nova Scotia—Chester	—	1	13	21	—
Maine—Lewiston	2	—	7	5	—
Maine—Lewiston	—	3	18	10	—
Vermont—So. Strafford	3	—	34	28	—
Vermont—So. Strafford	—	2	13	15	—
Vermont—Norwich E.	—	12	79	79	—
New Hampshire—Hanover	4	—	17	14	1=$T/+$
New Hampshire—Hanover	—	3	18	21	—
Connecticut—Mansfield	2	—	6	12	—
Connecticut—Mansfield	—	7	128	126	—
New York—Riverhead, L. I.	1	—	11	9	—
New York—Riverhead, L. I.	—	3	58	60	1=$T/+$
New York—Great Gull Isld.	3	—	16	13	—
New York—Great Gull Isld.	—	37	1105	946	—
New York City—West Side	4	—	34	21	—
N. Carolina—Raleigh	—	2	129	145	1=$T/+$
S. Dakota—Brookings	1	—	9	12	—
S. Dakota—Brookings	—	2	77	69	1=$T/+$
Montana—Clinton	—	11	290	337	—
California—Adin	—	1	18	14	—

Total Tested: 20 ♀♀, 84 ♂♂

The fact that it is over 25 per cent (50% heterozygous) was sufficiently astonishing at the time, considering that both of the alleles are subject to a very strong negative selection, but we felt that little weight could be given to this because the population had been inbred in small numbers for several generations. It was clear that it had not attained the equilibrium values to be expected under the model, assuming a male transmission ratio of .96.

Turning to the other populations, of which only small samples were tested, it is evident that in only two cases (Connecticut 2 and Texas 2) does the frequency of the variant allele approach the proportions expected in the model. The general frequency of heterozygotes for *t*-alleles in populations other than New York 1 was 24 out of 69 tested, that is, about 35 per cent. Because of the variations in frequency from population to population, this average has little meaning, but the general conclusion can be drawn that it is unlikely that the frequency of *t*-alleles in wild populations is as high as was predicted from the model.

This result suggested that other factors oppose the increase in frequency of lethal alleles predicted from the high male transmission ratio. Attempts have been made to test one such factor, natural selection operating against heterozygotes, that is to say partial dominance of the lethal allele. No evidence of this has been found in two experimental tests (Dunn and Suckling, 1956; Dunn,

Beasley and Tinker, 1958). The results indicated rather that male heterozygotes have higher fitness than males homozygous for the normal allele. The effects of other factors opposing the spread of lethals, such as inbreeding in very small populations, sexual selection favoring males without a lethal, and discrimination against heterozygotes by special habitat conditions, have not yet been tested. At present we are able to specify one condition favorable to the maintenance of polymorphism for *t*-alleles, namely high male transmission ratios of all such alleles derived from wild populations, but are unable to explain the failure of such alleles to attain the equilibrium values expected if transmission ratio is the decisive factor.

GEOGRAPHIC DISTRIBUTION OF SIMILAR ALLELES

Thirteen lethal alleles, each derived from a different wild population, have been tested by intercrossing in all possible combinations to determine whether alleles derived from different populations are non-identical. The method and most of the results obtained have been described elsewhere (Dunn, 1957*b*). In brief, lethal alleles such as t^n and t^x from two different sources are judged to be non-identical if the compound between them, t^n/t^x, is viable and normal. The cross of two true-breeding tailless lines T/t^n x T/t^x, yields in this case two phenotypes at birth; tailless (T/t^n, T/t^x) and normal-tailed (t^x/t^n). The third combination T/T is lethal before birth. Alleles having this relation are assigned to different groups; those which, when intercrossed, give only tailless progenies are tentatively assigned to the same group. Embryological examination of homozygotes from such intragroup matings is required to confirm whether the lethals assigned to the group are in fact similar (Bennett and Dunn, 1958). Viable alleles obviously differ from lethal ones but cannot at present be distinguished from each other and are all assigned to the same group. Application of this test to thirteen alleles from wild populations discloses that they fall into three groups. Group 1 consists of three viable alleles: t^{w2} (New York 1); t^{w7} (Texas 1); t^{w8} (Virginia). Group 2 contains three lethal alleles, the homozygous effects of which are indistinguishable: t^{w1} (New York 1); t^{w3} (Connecticut 1); t^{w12} (California). Group 3 contains nine indistinguishable alleles: t^{w5} (New York 2); t^{w6} (Sarasota, Florida); t^{w10} (Mon-

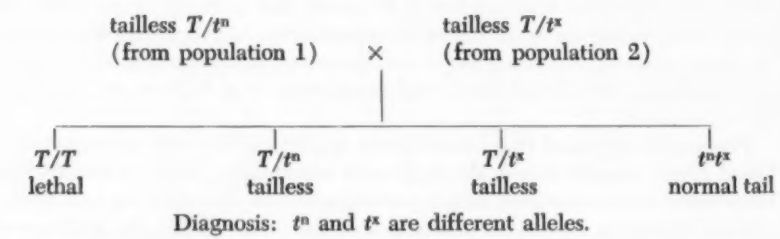


FIG. 2.—Method of testing for non-identity of lethal *t*-alleles from different populations.

tana); t^{w11} (Connecticut 2); t^{w13} (Texas 2); t^{w14} (Vermont 1a); t^{w15} (Kansas); t^{w16} (Vermont 1b); t^{w17} (Arizona).

It is obvious that the groups do not correspond to any simple geographic pattern. If the alleles in any one group are in fact identical (a point very difficult to establish) and can be assumed to have had a common origin in one mutative event, then the allele may have been dispersed in some apparently random way, possibly by human agencies. Adaptive relations between particular alleles and special habitats have of course not been tested and so are not excluded.

The above lethal alleles have been tested in crosses with three lethal alleles of laboratory origin (t^0, t^1, t^{12}) and are non-identical with these.

An allele derived from a Wisconsin population (t^{w4}) appeared not to differ from a laboratory allele t^0, and since there was a possibility that there had been contact between the population and laboratory mice in Madison this allele was discarded and not studied further. Similar doubts led to the exclusion of an allele, t^{w9}) captured about a quarter of a mile from Columbia University.

POPULATIONS IN WHICH NO *T*-ALLELE WAS FOUND

In small samples from each of 13 populations, no heterozygote was detected (Table 2). However, only three of the samples were large enough to indicate that the allele was either absent or present in very low frequencies. The largest sample was that from Great Gull Island in Long Island Sound. This is an uninhabited island formerly garrisoned by the Coast Artillery, but unoccupied since World War II. Several collections of these wild mice during the years 1955, 1956 and 1957 yielded a total of 40 animals (37 males, 3 females) which bred in the laboratory. The 37 males were exhaustively tested, and no heterozygotes were detected. Twelve males collected in buildings on three farms in Norwich, Vermont, and eleven males from Clinton, Montana, failed to include a heterozygote. Other samples were too small or yielded too few test offspring to give information on polymorphism at this locus.

These results show that although polymorphism for *t*-alleles, usually lethal alleles, is a common condition in wild populations, it has not spread through the whole species. It may be significant that the only large sample found to be free of a *t*-allele was from an island population. The two advantages enjoyed by *t*-alleles, that is, high transmission ratios and higher fitness of heterozygotes, should favor their spread in and from any population in which such an allele occurs. Limitation in the extent of home ranges and in the size of local populations would modulate but not inhibit the diffusion of such alleles. Whether similar factors control the gene frequencies both within and between populations is an interesting question deserving further study.

POLYMORPHISMS FOR OTHER CHARACTERS

Several other characters were found to vary both within and between populations. Table 3 gives a summary of the most obvious external variations noted.

All mice captured (with one exception, see below) were of the black agouti phenotype. The gray-bellied form, commonly considered as the "wild type," occurred in all populations but most samples included animals in which there was a sharp color distinction between dorsal and ventral surfaces. The commonest variant was the white-bellied form, with yellow-bellied and light- or cream-bellied forms almost equally frequent. Most populations were obviously polymorphic for these patterns. Variations in intensity of the dorsal agouti pattern were noted in four populations; light color (less black) associated with white belly (see below) in two populations; dark color (more black) in two populations. White spotting was found in six out of thirteen samples: as a head spot or blaze in four, a belly spot in three, and as white feet in three. Tail spotting was not routinely recorded but certainly occurred in several samples.

One extreme white-spotted variant, a male, was caught 9 January 1956 by Farm Adviser Carl W. Rimbey on the Marcel Kresge ranch near Adin, near the southern border of Modoc County, California. It was sent to Walter E. Howard, Field Station Administration, University of California, at Davis, who very kindly sent it to us in July 1956, together with a normal wild female captured in Davis and two litters of nine normal young from matings of the spotted male by the wild female. The spotted male was agouti splashed all over with small spots of white, resembling the extreme form of variegation sometimes seen in the genotypes *WwSS* and *WsSs* (Dunn, 1937). In our laboratory he produced, when mated with a black pied (*ss*) female, six normal agouti, self-colored offspring. These when mated inter-se produced six self-colored offspring and one pied like the pied grandmother. One of the F_1 males sent

TABLE 3.—*Occurrence of variant phenotypes in wild house mice from different locations (trapping sites). + indicates presence of the variant*

POPULATION	BELLY COLORS (A^L SERIES)				SPOTTING			OVER-ALL COLORATION		
	gray	light	yellow	white	head	belly	feet	normal agouti	light agouti	dark agouti
New York 1*	+		+	+		+		+		
Gt. Gull Isld. (L. I. Sound)	+							+		+
Storrs, Conn.	+			+				+	+	
Mystic, Conn.	+				+			+		
Mansfield, Conn.	+			+				+		
Norwich, Vt.	+	+	+				+	+		+
Rumford, Va.	+	+	+	+	+	+	+	+	+	
Sarasota, Fla.	+	+		+	+			+		
Austin, Tex.	+	+		+				+		
Tucson, Ariz.	+	+						+		
Lawrence, Kan.	+			+				+		
Modoc, Calif.	+				+	+	+	+		
Madison, Wisc.	+	+	+					+		
Brookings, S. D.	+		+	+				+		

* From wild mice trapped in New York City and Philadelphia, Pa.

by Dr. Howard produced, when mated with normal agoutis from our laboratory stock, 26 normal agoutis, and inter-se matings amongst these produced 35 self-colored agoutis. Other F_1 mice failed to breed. The data are adequate to exclude the possibility that the variant male carried a dominant gene like *W*, but not sufficient to exclude that he was homozygous for a recessive allele for spotting, other than *s*. A direct test showed that he was not *ss*. The cause of the pattern in this most unusual variant remains unknown.

More detailed descriptions of the variety found in two populations will be given as examples of the phenotypic polymorphism found in most populations.

The variety in the Virginia population was especially striking. Ten females and 15 males were captured between November 1954 and July 1955 in the grain barn of Andrew Beasley near Rumford, Virginia. Two males out of eleven animals (8 males, 3 females) which bred in the laboratory proved to be $+/t^w$. Of the 25 captured animals, only four were gray-bellied agouti; sixteen were agouti with pure white bellies, and of these eight were very light-colored all over due to long light-yellow bands on the agouti hairs, and five were agouti with yellow or cream-colored bellies. The white and yellow-bellied phenotypes resemble those of animals with A^w or A^L alleles of the A series and populations are known to be polymorphic for these alleles (see Gruneberg, 1952, pp. 37–38). However, other genes not at the agouti locus are also known to influence the belly color. One such variant called "snowy-belly" was found by Eaton and Schwarz (1946) in a wild mouse captured in Arlington, Virginia; their breeding data indicated that snowy-belly was due to a gene or genes not at the *A* locus, although they did not so interpret their data. Falconer (1947) showed that snowy-belly is due to multiple factors and not to an allele of *A*. Since in the present case, no breeding analysis of the white-bellied light-colored animals was made, it can only be stated that the population was polymorphic for a gene or genes influencing both the over-all color and the belly color. In addition, four animals (all with white bellies) had white spots ("blazes") between the eyes. The population thus exhibited at least three different polymorphisms.

TABLE 4.—*Brachy (T/+) offspring of wild parents test-crossed by Brachys (T/+) of an inbred laboratory stock*

POPULATION	WILD PARENTS TESTED	TAIL LENGTH OF T/+ OFFSPRING								
		0	⅛	¼	⅜	½	⅝	¾	⅞	TOTAL
Oakland, Calif.	13	—	—	2	5	31	36	97	26	197
Raleigh, N. C.	2	1	2	7	12	36	41	35	11	145
Mansfield, Conn.	6	—	—	1	—	1	22	61	13	98
Riverhead, L. I., N. Y.	3	—	4	5	4	20	13	5	2	53
Gull Island	33	1	—	—	—	11	165	494	166	837
Clinton, Mont.	11	1	2	7	30	49	98	49	8	244
Wisconsin 2	10	—	5	20	—	91	—	64	4	184
Wisconsin 3	5	—	2	1	—	24	—	29	14	70

Extensive collections were made on the Metcalf Farm on Dutton Hill, west of Norwich, Vermont. Fifty-six mice (36 males, 20 females) were trapped in the farmhouse and ten farm buildings and outhouses. Of the males, 26 were gray-bellied agouti, four white-bellied agouti, and four yellow-bellied agouti. One of the gray-bellied agoutis had a white head spot, another was very dark, and another had white legs. All 20 females were gray-bellied agouti, one with a white head spot. On three other farms in Norwich twelve males were caught, all agouti, eleven with gray bellies, one with yellow belly.

MODIFIERS OF TAIL LENGTH

In Table 2 it will be seen that four populations contained animals which, while lacking a *t*-allele, nevertheless produced an occasional tailless offspring when crossed with Brachy ($T/+$). All such exceptions were tested and found to be $T/+$; this genotype, which in our laboratory stocks produces a tail about ¾ of normal length, may be modified by other genes which vary in the wild populations.

A study of this effect is summarized in Table 4. It is apparent that the Brachy offspring of wild mice in all of these populations have tail lengths shorter than those which occur in the stock from which the Brachy tester females were taken. The range in this stock in the F_{10}–F_{16} generations was from one-half to seven-eighths of normal length in the tails of the Brachys, with mode at three-fourths. The same mode is characteristic of F_1 Brachys from crosses with only three wild populations; with five others the mode is below three-fourths, and many F_1 Brachys had very short tails or none at all. This indicates that many wild populations are polymorphic for modifiers which shorten the tail when combined with the dominant allele *T*.

The skeletons of wild mice from several populations have been studied by Deol (1958), who has found many minor variations which differ from population to population.

SUMMARY

Samples of wild house mice from some 30 different populations (trapping sites) in different parts of the United States show a remarkable degree of polymorphism. The most important finding, from an evolutionary standpoint, is that most wild populations contain animals of two genotypes, one with ($+/t$), and one without ($+/+$), a mutant allele at locus *T*. The *t*-alleles found in wild mice are recessive, but produce a tailless phenotype when combined with a dominant marker allele, *T* (Brachyury), from a laboratory stock. Of 16 such alleles isolated, each from a single wild heterozygote, and studied genetically and in some cases embryologically, 13 are lethals and three are viable with normal tails when homozygous (t/t).

The factor chiefly responsible for maintaining this polymorphism is an unusual property of all *t*-alleles in wild populations by which heterozygous males transmit the mutant alleles to from 90 to 99 per cent of their offspring. This would lead to the expectation that most of the members of wild populations would be heterozygous for *t*-alleles. The actual frequencies found are usually 50 per cent or below, and in a few wild populations no heterozygotes were found.

Three groups of *t*-alleles were found in wild populations: (1) viable alleles; (2) lethals which are allelic and have similar effects with death occurring late in embryogeny; (3) lethals nonidentical with the above with homozygous effects producing death early in embryogeny. The members of the same group appear in widely separated parts of the United States, possibly tracing to the same mutation which was dispersed by human means.

Other polymorphisms detected concern pelage pattern: white belly, yellow belly, cream belly; over-all light, over-all dark and white spotting of several kinds. Wild populations appear also to be polymorphic for modifiers which affect the tail length when combined with the dominant allele *T*.

LITERATURE CITED

BENNETT, D. AND L. C. DUNN. 1958. Effects on embryonic development of a group of genetically similar lethal alleles derived from different populations of wild house mice. Jour. Morph., 103: 135–157.

BRUCK, DAVID. 1957. Male segregation ratio advantage as a factor in maintaining lethal alleles in wild populations of house mice. Proc. Nat. Acad. Sci., 43: 152–158.

DEOL, MALKIAT. 1958. Genetical studies on the skeleton of the mouse. 24. Further data on skeletal variation in wild populations. Jour. Embryol. and Exp. Morph., 6: 569–574.

DUNN, L. C. 1937. Studies on spotting patterns. II. Genetic analysis of variegated spotting in the house mouse. Genetics, 22: 43–64.

———. 1957*a*. Evidence of evolutionary forces leading to the spread of lethal genes in wild populations of house mice. Proc. Nat. Acad. Sci., 43: 158–163.

———. 1957*b*. Studies of the genetic variability in populations of wild house mice. II. Analysis of eight additional alleles at locus T. Genetics, 43: 299–311.

———, AND JOAN SUCKLING. 1956. Studies of the genetic variability in wild populations of house mice. I. Analysis of seven alleles at locus T. Genetics, 41: 344–352.

———, A. B. BEASLEY AND HARRIET TINKER. 1958. Relative fitness of wild house mice heterozygous for a lethal allele. Amer. Nat., 92: 215–220.

EATON, ORSON N. AND E. SCHWARZ. 1946. The "snowy belly" mouse. Jour. Hered., 37: 31–32.

FALCONER, D. S. 1947. Genetics of "snowy-belly" in the house-mouse. Jour. Hered., 38: 215–219.

GRÜNEBERG, HANS. 1952. The genetics of the mouse. Martinus Nijhoff, The Hague. 643 pp.

Columbia University, New York City. Received 13 November 1958.

[Research carried out at Nevis Biological Station, Irvington-on-Hudson, New York, under Contract AT (30–1) 1804 with the U. S. Atomic Energy Commission. The assistance of Frank Burnett, Bill S. Boland and Charlotte Stoeuber is gratefully acknowledged.]

NOTES ON *SOREX* IN THE NORTHERN ROCKY MOUNTAIN ALPINE ZONE

By Robert S. Hoffmann and Richard D. Taber

Field work in the summers of 1957 and 1958 in the northern Rocky Mountains of Montana and adjacent Wyoming has provided new information on two species, *Sorex vagrans* and *S. nanus*, which occur at high altitudes in this area. All specimens are deposited in the Montana State University Zoological Museum. We wish to thank Philip Shelton and Samuel Bamberg for assistance in the field, and Hartley H. T. Jackson and John Paradiso for confirming the identity of the specimens of *Sorex nanus*. The field work was supported in part by National Science Foundation Grant No. 5174 to Montana State University, and by the Montana Cooperative Wildlife Research Unit.

Sorex vagrans.—The vagrant shrew occurs in moist hydrophytic communities of the high subalpine to alpine zones. Clothier (1955) reported that it had not been taken above 5,300 feet. He failed to collect it in 400 trap-nights in the Logan Pass area of Glacier National Park, at 6,000–6,700 feet, and no specimens had been taken here in regular summer trapping from 1948 through 1956 (P. L. Wright, *in litt.*). However, on 22 and 23 July 1957, four individuals were taken at Logan Pass, three in snap traps and one by hand. Habitat and associated mammals are given in Table 1.

In a comparable trapping period in July 1958, no vagrant shrews were taken at Logan Pass, but they were obtained in two other alpine areas during that summer. Trapping 25 miles southwest of Red Lodge in the Beartooth Plateau, Shoshone County, Wyoming, at 10,100 feet elevation, produced two *Sorex vagrans* from 15–17 June 1958. Further trapping in the same area from 31

Table 1.—*Plant and mammal associates of alpine Sorex vagrans*

No. of *S. vagrans* caught	Area	Habitat, plant associates	Mammal associates
3	Logan Pass	Near stream; *Salix commutata, Carex, Phyllodoce*	*Microtus richardsoni, Peromyscus maniculatus Citellus columbianus*
1	Logan Pass	Meadow; *Erythronium grandiflorum, Carex, Luzula*	*Phenacomys intermedius*
7	Beartooth Plateau	Near stream; *Salix wolfii, Deschampsia caespitosa, Carex scopulorum*; growing on water-saturated hummocks	*Microtus richardsoni, Microtus montanus*
4	Crazy Mountains	Moist meadow below solifluction terraces; *Deschampsia caespitosa, Festuca ovina* var. *brachyophylla*	*Phenacomys intermedius*

August to 2 September 1958 yielded five more. All were taken in one line of snap traps (60 traps/line) set in *Microtus richardsoni* runways along a small stream. On 2–4 July 1958, at the head of Big Timber Creek, Crazy Mountains, Sweet Grass County, Montana, 10,000 feet elevation, four more *S. vagrans* were taken from two trap lines run for three days.

Data on reproduction in these specimens are presented in Table 2. The fact that adults of both sexes are included among the specimens strongly suggests that these shrews were members of resident populations, rather than stragglers from lower elevations.

Sorex nanus.—The dwarf shrew is known from about 15 specimens from Arizona, New Mexico, Colorado, Utah, Wyoming and South Dakota. The northernmost of these previous records was at South Cascade Canyon, Grand Teton National Park, Wyoming, at 10,050 feet (Durrant and Lee, 1955). On

TABLE 2.—*Sorex vagrans trapped in the Alpine Zone*

No.	Date captured	Locality	Sex	Age*	Reproductive condition
RSH 598	16 June	Beartooth Plateau	♂	Ad.	Testes 6 × 3.5 mm.; breeding condition
617	17 June	Beartooth Plateau	♀	Ad.	Uterus turgid, 1.5 mm. diameter; no visible embryos or placental scars; probably ready to ovulate or in early pregnancy
736	31 Aug.	Beartooth Plateau	♀	Juv.	Uterus 1 mm. diameter; immature
746	1 Sept.	Beartooth Plateau	♂	Juv.	Testes minute; immature
823	2 Sept.	Beartooth Plateau	♂	Ad.	Testes 6 × 3.5 mm.; breeding condition
826	2 Sept.	Beartooth Plateau	♀	Juv.	Uterus .5 mm. diameter; immature
827	2 Sept.	Beartooth Plateau	♂	Juv.	Testes minute; immature
PCS 52	2 July	Crazy Mountains	♀	Ad.	9 embryos, 4R, 5L; size in utero 2 × 4 mm.
53	2 July	Crazy Mountains	—	Juv.	Viscera eaten while in trap
54	2 July	Crazy Mountains	♂	Ad.	Testes 5 × 3 mm.; breeding condition
71	3 July	Crazy Mountains	♂	Ad.	Testes 6 × 4 mm.; breeding condition
RSH 852	22 July	Logan Pass	♂	Ad.	Testes 5 × 3 mm.; breeding condition
856	22 July	Logan Pass	♂	Ad.	Testes 5.5 × 3.5 mm.; breeding condition
429	23 July	Logan Pass	♂	Ad.	Testes 6 × 3.5 mm.; breeding condition
430	23 July	Logan Pass	♀	Juv.	Uterus threadlike; immature

* Based on tooth wear.

31 August and again on 2 September 1958, single dwarf shrews were taken in a trapline on the alpine tundra of the Beartooth Plateau, 30 miles southwest of Red Lodge, at an altitude of 10,900 feet. The habitat sampled (180 trap-nights) was a polygonal rock field in which rock gutters alternate with patches of vegetation. The vegetation clothing the soil between the rock polygons was dominated by dry tundra forms such as *Carex scopulorum, Geum rossi, Trifolium nanum, Silene acaulis, Phlox caespitosa* and *Pedicularis racemosa.* The only other small mammal taken on this line was a single adult female *Peromyscus maniculatus,* but *Ochotona princeps* and *Marmota flaviventris* were common in the area. Both shrews were caught in Museum Special snap traps.

A third specimen of *Sorex nanus* was taken from Yogo Peak in the Little Belt Mountains, Judith Basin County, Montana, at 8,700 feet elevation. A trapping period in the alpine zone there on 18–20 June was terminated by a heavy snowfall. The traps could not be recovered immediately, but were picked up on 5 July. A number of specimens in various stages of decomposition were recovered from the traps. Among these were two small shrews; one was subsequently lost, but the other, an adult with well-worn teeth, was identified as *Sorex nanus.* Only the skull could be saved. This individual was trapped in a dry tundra fellfield in which spaced surface rocks provided cover for small mammals. The vegetation of this fellfield consisted of mat plants similar to the polygon field on the Beartooth, but the dominant species differed, being *Arenaria obtusiloba, Carex elynoides, Festuca ovina* var. *brachyophylla* and *Selaginella densa.* Here the surface rocks did not form deep gutters, breaking the vegetation into patches, as was the case in the polygon field. Other species taken on the trapline included nine *Peromyscus maniculatus,* two *Phenacomys intermedius* and two *Eutamias amoenus.*

It is of interest that most previous specimens of *S. nanus* have come from subalpine forest communities. The only other one from rocky alpine tundra, as were ours, is the one mentioned by Durrant and Lee (1955). The specimens here reported extend the known range of *Sorex nanus* northward approximately 100 and 215 miles, respectively. The skull from the Little Belt Mountains represents the first record of this species from Montana, if the specimen reported by Merriam (1895: 82) from Fort Custer (now near Hardin, Big Horn County, elevation 3,000 feet) be discounted. [Jackson (1928: 175) reported that he was "unable to locate the Montana specimen or to find any record of it other than that published by Merriam."] Although this was the first record of *S. nanus,* Merriam discussed only its occurrence in Colorado and said nothing about it in Montana; it is merely mentioned under *Specimens examined.* In the same paper, Merriam reported from Fort Custer only two other species of shrews, eight specimens of *S. personatus* (=*cinereus*) and the type specimen of *S. merriami.* It is possible that the report of *S. nanus* at Fort Custer was an error engendered by the first record of *S. merriami* at the locality. This seems more likely in view of the known altitudes of occurrence of *S. nanus.* Durrant and Lee (1955) first pointed out that all specimens known to them were taken

above 8,000 feet and subsequent specimens have also come from high montane habitats above 7,500 feet, with one exception. This is a partial skull recovered from a shrew found dead in a stubblefield near Fairburn, Custer County, South Dakota, at an elevation of approximately 3,300 feet. It was first identified as *S. vagrans* (Baker and Findley, 1953) but this was later revised to *S. nanus* (Findley and Baker, 1956). The specimen is unique among those identified as *S. nanus* in both its low altitude and its habitat.

In discussing the past and present distribution of the *S. vagrans* and *S. ornatus* groups in the west, Findley (1955) postulated that the form ancestral to *S. vagrans-ornatus-longirostris-veraepacies* was forced south by the penultimate Pleistocene glaciation (the Illinoian), and that in the interglacial period which followed (Sangamonian), desiccation in the central and southwestern regions isolated segments of the ancestral form in such places as coastal California, the Sierra Nevada, and the mountains of Arizona and New Mexico. The ancester of *S. nanus* then "may have occurred in the Black Hills and isolated mountains of Arizona and New Mexico during the Sangamonian interval and remained in these general areas during the Wisconsin age. Its present range is peripheral to the main body of the Rockies and the Colorado Plateau" (Findley, 1955: 28). This interpretation suggested that, during the last glacial advance, *S. nanus* inhabited areas south and east of the icesheets and has undergone little change in range since then; this was reasonable in view of the distribution of specimens available at that time. However, specimens now available serve to show that the species must have come to occupy in Recent time areas which were covered by the Wisconsin glaciation (Flint, *et al.*, 1945). Such areas are the Beartooth Plateau, Grand Teton National Park, and Medicine Bow Mountains in Wyoming (Mickey, 1948). Other localities of occurrence which were very close to, if not covered by, icesheets, are Estes Park and Silver Plume, Colorado (Merriam, 1895; Von Bloeker, 1944). It should also be pointed out that the localities of occurrence of *S. nanus* in Arizona and Utah, at Grand Canyon National Park and San Juan County, respectively (Schellbach, 1948;

TABLE 3.—*Sorex nanus trapped in the Alpine Zone*

No.	Date captured	Locality	Sex	Age	Reproductive condition
RSH742	31 Aug.	Beartooth Plateau	♂	Juv.	Testes minute; immature
749	2 Sept.	Beartooth Plateau	♀	Juv.	Uterus threadlike; immature
PCS 96	20 June–5 July	Little Belt Mountains	—	Ad.	?

No.	MEAS., mm.				CRANIAL MEASUREMENTS, mm.					
	tot.	tail	h.f.	Wgt. gm.	C-B leng.	Pal. leng.	Cran. breadth	Int. breadth	Maxil. breadth	Maxil. toothrow
RSH 742	90	38	11	2.5	14.4	5.8	6.9	2.9	4.0	5.3
749	94	45	10	2.5	14.5	5.9	7.1	2.9	4.0	5.4
PCS 96	—	—	—	—	14.1	5.6	6.8	2.8	3.9	5.3

Hoffmeister, 1955; Durrant and Lee, 1955), are well within the Colorado Plateau as it is defined by geologists (Eardley, 1951: 285). It seems likely that *S. nanus* is of wider distribution than available specimens suggest since, up to the present time, almost every new record of the species has resulted in a significant extension of its known range.

The measurements and pertinent data on the three new specimens of *S. nanus* are presented in Table 3.

SUMMARY

New data on the occurrence of *Sorex vagrans* and *S. nanus* in the alpine zone of the northern Rocky Mountains are given. *Sorex vagrans* was obtained in streamside *Salix*, streamside *Carex-Phyllodoce* and *Deschampsia-Festuca* meadow biotopes, in Glacier National Park and the Crazy Mountains, Montana, and on the Beartooth Plateau, Wyoming. The species ranged up to 10,100 feet. *Sorex nanus* was obtained in the Little Belt Mountains, Montana, 8,700 feet, in an alpine fellfield, and on the Beartooth Plateau, Wyoming, 10,900 feet, in an alpine polygon field.

LITERATURE CITED

Baker, R. H. and J. S. Findley. 1953. *Sorex vagrans* first reported from South Dakota. Jour. Mamm., 34: 382.

Clothier, R. R. 1955. Contribution to the life history of *Sorex vagrans* in Montana. Jour. Mamm., 36: 214–221.

Durrant, S. D. and M. R. Lee. 1955. Rare shrews from Utah and Wyoming. Jour. Mamm., 36: 560–561.

Eardley, A. J. 1951. Structural geology of North America. Harper and Bros., New York. 624 pp.

Findley, James S. 1955. Speciation of the wandering shrew. Univ. Kansas Publ., Mus. Nat. Hist., 9: 1–68.

Findley, J. S. and R. H. Baker. 1956. Dwarf shrew first reported in South Dakota. Jour. Mamm., 37: 543.

Flint, R. F. *et al.* 1945. Glacial map of North America. Geol. Soc. Amer., Spec. Paper No. 60, Pt. 1.

Hoffmeister, D. F. 1955. Mammals new to Grand Canyon National Park, Arizona. Plateau, 28: 1–7.

Jackson, H. H. T. 1928. A taxonomic review of the American long-tailed shrews (Genera *Sorex* and *Microsorex*). N. Amer. Fauna 51: 1–218.

Merriam, C. H. 1895. Synopsis of the American shrews of the genus *Sorex*. N. Amer. Fauna 10: 57–100.

Mickey, A. B. 1948. A record of the shrew *Sorex nanus* for Wyoming. Jour. Mamm., 29: 294–295.

Schellbach, Louis, III. 1948. A record of the shrew *Sorex nanus* for Arizona. Jour. Mamm., 29: 295.

Von Bloeker, J. C., Jr. 1944. New locality records for some west American shrews. Jour. Mamm., 25: 311–312.

Dept. of Zoology and School of Forestry, Montana State Univ., Missoula. *Received 26 January 1959.*

THE STATUS OF THE GRAY-NECKED CHIPMUNK IN NEW MEXICO

By E. D. Fleharty

Three subspecies of the gray-necked chipmunk, *Eutamias cinereicollis* (Allen), are currently recognized. Chipmunks referred to as *Eutamias c. cinericollis* (Allen) occur in the San Francisco Mountains of Arizona and extend southeasterly on the Mogollon Plateau, and into the White Mountains in eastern Arizona. Animals of the race *Eutamias c. cinereus* Bailey occur in the Mogollon, Black, San Mateo, and Magdalena ranges in New Mexico, while chipmunks comprising *E. c. canipes* Bailey are found in New Mexico east of the Rio Grande Valley in the Gallinas Mountains near Corona, in the Jicarilla, Capitan, White, and Sacramento Mountains, and in the Guadalupe Mountains of Texas.

My study of chipmunks from New Mexico revealed a marked difference between *E. c. canipes* and the other subspecies of *E. cinereicollis,* and the problem arose as to the relationship and identity of these and other populations of *E. cinereicollis.* The purpose of this report is to present data and tentative conclusions bearing on this problem.

I greatly appreciate the suggestions received during the course of this work from Professor James S. Findley, who guided me in research and supervised the writing of this manuscript. I am grateful to Professors W. B. Davis, D. F. Hoffmeister, E. L.Cockrum, and E. R. Hall, who are in charge of the collections from which specimens were borrowed. A. H. Harris provided the illustrations of the bacula. I received financial support from the National Science Foundation during the summers of 1957 and 1958, enabling me to complete a substantial amount of the field work.

The first to deal comprehensively with chipmunks of the species *E. cinereicollis* was Arthur H. Howell (1929: 98–102). He stated that those chipmunks from the southeastern mountains in New Mexico, currently recognized as *Eutamias cinereicollis canipes,* approach the Mexican species *E. bulleri* (Allen) in several characteristics, such as in the breadth and blackness of the ocular stripe and in the large size of the skull, and that *E. c. canipes* might possibly represent a distinct species.

The most recent student to deal with the relationships of these chipmunks was White (1953*a* and *b*). Using the baculum as an aid in separating chipmunks into groups and species, he reviewed the chipmunks of western North America but did not alter the groupings, as then recognized, of chipmunks in New Mexico. His material included only one baculum of *E. cinereicollis,* this from the White Mountains of Arizona, and only two of *E. bulleri,* these from Sierra de Valparaiso, Zacatecas.

Of the 161 skins and skulls assembled for this study, 100 were those of adult animals, while 56 of the specimens included the baculum. Unless otherwise indicated, the specimens are preserved in the University of New Mexico Collection of Vertebrates. Specimens borrowed from other institutions are identified by the initials AU (University of Arizona, Department of Zoology), TCRC

(Texas Cooperative Research Collection, Agricultural and Mechanical College of Texas), UI (University of Illinois, Museum of Natural History), and KU (University of Kansas, Museum of Natural History).

The chipmunks were separated into three age classes on the basis of the condition of the third upper molar. Animals were designated as adults if the molar was so worn that the dentine could be seen, as subadults if the molar was fully erupted but dentine was not visible, and as juveniles if the molar was not fully erupted.

Because adults differed from subadults in the external and cranial measurements, only adult individuals were used in studies of geographic size variation. Since no difference was found to exist between the bacula of adults and subadults, both were used in the bacular studies. No significant differences were noted between adult males and females in cranial and external measurements, and so the sexes were combined in the statistical treatments of the samples. Only those animals designated as adults and in full summer pelage were used in the comparison of color. All cranial and bacular measurements were taken by me. The cranial measurements were taken with a dial caliper and the bacular measurements with an eyepiece micrometer in a binocular microscope.

Cranial measurements taken were greatest length of skull, zygomatic breadth, least interorbital breadth, cranial breadth, cranial depth, alveolar length of maxillary tooth-row, length of nasals, and width of nasal bones. All measure-

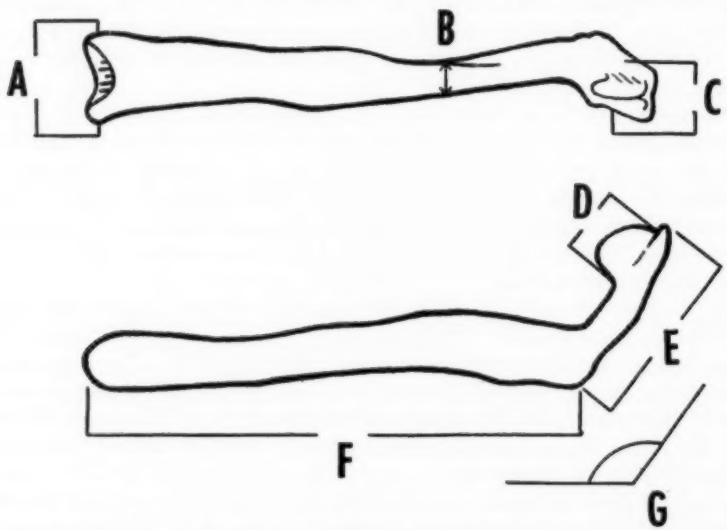


FIG. 1.—Locations where bacular measurements were taken. Based on the baculum from *Eutamias q. quadrivittatus*, from Sandia Crest, Sandia Mountains, Bernalillo Co., New Mexico, UNMCV 3301. × 20. Upper figure is a dorsal, and lower a lateral view. See text for explanation of symbols.

ments except the latter are as defined by Cockrum (1955: 34–37). The width of nasal bones was taken between the junctures of the premaxillary, frontal, and nasal bones on either side of the rostrum.

External measurements taken were total length, length of tail, length of hind foot, and height of ear from notch (Cockrum, 1955: 33).

The bacular measurements taken were as follows (see Fig. 1):

Width of base (*A*).—The greatest width of the base.

Width of shaft (*B*).—The least width of the shaft.

Width of tip at keel (*C*).—Width of tip on a level with the highest point of the keel.

Length of keel (*D*).—The greatest length parallel to the long axis of the tip.

Length of tip (*E*).

Length of shaft (*F*).—The greatest length along the ventral side of the shaft, from the most proximal point to the point where the tip begins.

Angle formed by shaft and tip (*G*).—The angle enclosed by a line between the most ventral portion of the base and the ventral point where the tip begins and a line between the origin of the tip and the distal end of the tip.

Bacula of the chipmunks were cleaned by first soaking them briefly in water and then in a 2 per cent KOH solution in a warm water bath for approximately 3 minutes. After removal from the KOH solution, the soft tissue was removed by teasing.

The baculum of *Eutamias* has a proximal portion termed the shaft, a distally upturned portion known as the tip, and a ridge projecting dorsally from and parallel to the long axis of the tip called the keel. The shaft, which is longer

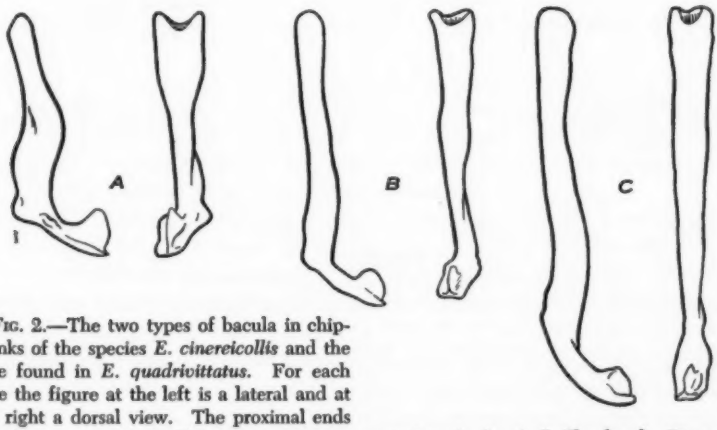


FIG. 2.—The two types of bacula in chipmunks of the species *E. cinereicollis* and the type found in *E. quadrivittatus*. For each type the figure at the left is a lateral and at the right a dorsal view. The proximal ends are above. × 10. *A*, *Eutamias canipes sacramentoensis*, 1 mi. S Cloudcroft, Otero Co., New Mexico, UNMCV 2988 (Type I). *B*, *Eutamias q. quadrivittatus*, Sandia Crest, Bernalillo Co., New Mexico, UNMCV 3301. *C*, *Eutamias cinereicollis*, 10 mi. E Mogollon, Catron Co., New Mexico, UNMCV 3121 (Type II).

than the tip, has no projecting ridges, but does have a dextral twist where it narrows. The hollow proximal end of the shaft is the widest part of the shaft and is termed the base. The tip, which bears the keel, has no other prominent irregularities.

Two distinct types of bacula are found among chipmunks of the species *Eutamias cinereicollis*. These types differ in length of shaft, width of base, and angle formed by shaft and tip, as well as in general shape. The two types, designated for convenience Types I and II, are shown in Fig. 2.

Bacula of Type I have shorter shafts (2.97–3.40 mm.), wider bases (.84–1.00 mm.), and angles that are more acute (112–121.5°) than those of Type II. Type II bacula have longer shafts (4.27–5.72 mm.), narrower bases (.49–.87 mm.), and greater angles (136–148°).

Type I is found in chipmunks from the Gallinas, Capitan, Sacramento, and Guadalupe Mountains, currently referred to as *E. cinereicollis canipes*, and Type II in those animals from the San Francisco Mountains in Arizona, and the Mogollon, Black, San Mateo, and Magdalena ranges in New Mexico, referred to as *E. c. cinereicollis* and *E. c. cinereus*.

In general appearance, Type I bacula somewhat resemble those from specimens of *Eutamias bulleri durangae* Allen taken 3 to 7 miles southwest of Las Adjuntas, Durango. However, the bacula of *E. b. durangae* have longer shafts,

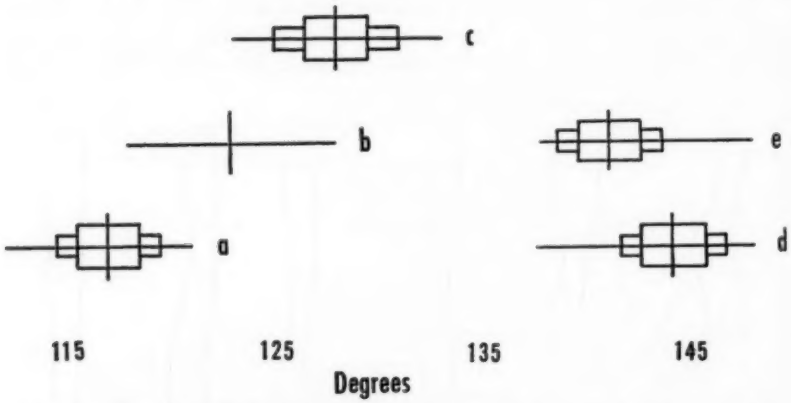


FIG. 3.—Angle formed by shaft and tip of baculum. The horizontal line represents the extremes; the vertical midline the arithmetic mean; the vertical lines closest to the mean enclose plus or minus 2 standard errors of the mean; and the vertical lines farthest from the mean enclose plus or minus 1 standard deviation of the mean. *a, Eutamias canipes sacramentoensis*, 1 mi. S Cloudcroft, Sacramento Mts., Otero Co., New Mexico (10 specimens). *b, Eutamias bulleri durangae*, 3 to 9 mi. SW Las Adjuntas, Durango (3 specimens). *c, Eutamias q. quadrivittatus*, Sandia Mts., Bernalillo Co., New Mexico (11 specimens). *d, Eutamias cinereicollis*, Willow Creek, Mogollon Mts., 10 mi. E Mogollon, Catron Co., New Mexico (13 specimens). *e, Eutamias cinereicollis*, Iron Canyon, Black range, 15 mi. E and 6 mi. N Santa Rita, Grant Co., New Mexico (14 specimens).

slightly wider bases, and slightly greater angles than do those of Type I. Both the Type I bacula and those from *E. bulleri durangae* differ from the baculum of *E. b. bulleri* (Allen) from Sierra de Valparaiso, Zacatecas, which was pictured by White (1953*b*: 628–629). The shafts of the bacula of *E. b. durangae* are longer, the angles are greater, and the heights of the keels are less than in *E. b. bulleri*. Type I bacula differ from those of *E. b. bulleri* in having larger angles and shorter keels. The shafts of the bacula of both Type I and *E. b. bulleri* are of approximately the same length. No bacula from *Eutamias bulleri solivagus* Howell were examined.

In addition, Type I bacula resemble the picture and measurements of the baculum from a specimen of *E. umbrinus umbrinus* (Allen) given by White (1953*b*: 626, 629). However, the baculum from this specimen has a shorter shaft and a smaller angle than do those of Type I.

The bacula of specimens of *E. c. canipes* differ greatly from those examples of *E. c. cinereus* and *E. c. cinereicollis*. Since there is fully as much difference between the bacula of *E. c. canipes* east of the Rio Grande and the two subspecies west of the Rio Grande as there is between those of full species as recognized by White (1953*b*: 615–629), the problem arises as to the status of *E. c. canipes*. On the basis of the baculum it cannot logically be regarded as a subspecies of *E. cinereicollis*. As mentioned above, the Type I bacula resemble in some ways both those of *E. bulleri* and of *E. umbrinus*. However, adequate series of bacula of the latter two species have not been examined by me. Further study may reveal a specific affinity between one or both of the latter and *E. c. canipes*.

A conservative course is followed here, and the chipmunks found in the Gallinas, Capitan, Sacramento, and Guadalupe Mountains are given the available epithet of *Eutamias canipes* Bailey, first applied to chipmunks of the Gaudalupe Mountains.

Within the range of *E. canipes* there is considerable geographic variation. For example, animals from the Sacramento Mountains are much larger and darker in color than are those from the Guadalupe, Capitan, and Gallinas Mountains. However, only four specimens from the Capitan Mountains and two from the Gallinas Mountains were examined.

Compared with specimens of *E. bulleri durangae* and *E. b. solivagus*, the animals from the Sacramento Mountains do not differ significantly in most cranial and external measurements. Animals from the Guadalupe Mountains are smaller in both cranial and external measurements than the above-mentioned subspecies of *E. bulleri*.

Chipmunks from the Sacramento Mountains differ from *E. cinereicollis* in larger size. Specimens of *Eutamias canipes* from the Guadalupe Mountains are paler in color but similar in size to animals designated as *E. cinereicollis*.

Within the range of *E. cinereicollis* there is little geographic variation in color or size. The populations of this chipmunk in the Magdalena and San Mateo Mountains differ from populations farther west in New Mexico and

Arizona in minor bacular and color differences. However, in this study chipmunks of the species *Eutamias cinereicollis* are not assigned to named subspecies. In a forthcoming study of the genus *Eutamias* in the Southwest, geographic variation in the species *Eutamias cinereicollis* will be fully reviewed.

The distinctive population of *Eutamias canipes* from the Sacramento Mountains may be formally described as follows.

Eutamias canipes sacramentoensis subsp. nov.

Type.—Obtained in the Sacramento Mountains, 1 mi. S Cloudcroft, altitude 9000 ft., Otero Co., New Mexico, on 4 July 1957, by Eugene D. Fleharty; adult male, skin, skull, and baculum; No. 2984, University of New Mexico Collection of Vertebrates; original number 90.

Range.—Known only from the Sacramento Mountains of New Mexico.

Diagnosis.—Size large, largest of the *E. quadrivittatus* group in New Mexico; average and extreme measurements of 14 specimens from the type locality are: total length, 245 mm. (227–264); tail, 102 mm. (91–108); hind foot, 34.6 mm. (34.0–36.0). General tone of upper parts dark; dark dorsal stripes black and dorsal light stripes gray; gray on shoulders and on dorsal surface of hind feet. Baculum with short shaft, wide base, and angle less than 121°; average and extreme measurements of ten bacula from the type locality are: length of shaft, 3.23 mm. (3.10–3.49); width of base, .91 mm. (.78–1.00); angle formed by shaft and tip, 117° (112–121°).

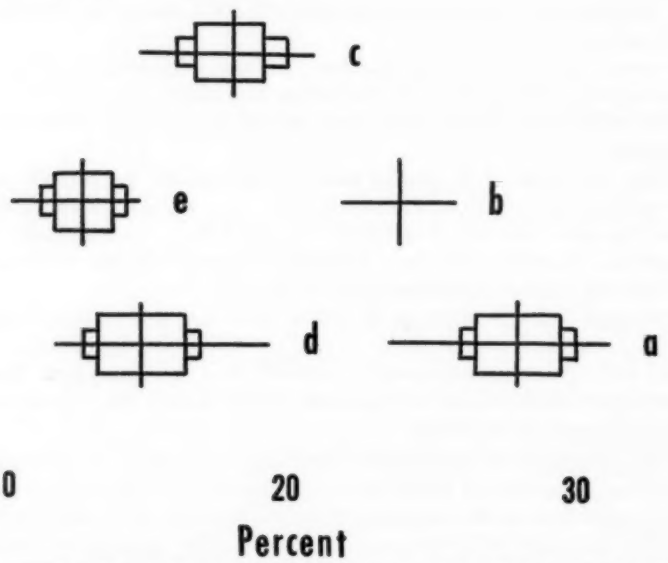


FIG. 4.—Width of base of baculum expressed as a percentage of the length of shaft. All symbols used represent the same populations and localities as in Fig. 3.

Comparisons.—Differs from topotypical *E. c. canipes* from the Guadalupe Mountains and those chipmunks from the Capitan and Gallinas Mountains in being darker and larger (see Figs. 4 and 5). There is no significant difference in bacular structure. From *E. cinereicollis, E. canipes sacramentoensis* differs in larger size and in the bacular differences mentioned above.

Remarks.—Those animals from the Gallinas and Capitan Mountains are not subspecifically assigned in this study because an insufficient number of specimens was collected to permit an understanding of the relationship of these animals with the named subspecies of *E. canipes.* The species has also been reported from the Malpais west of Carrizozo by Benson (1933: 24), but none of these animals was examined.

Specimens examined.—Total number, 161 (100 adults, 56 bacula).

E. canipes sacramentoensis, 14 adults, 10 bacula

NEW MEXICO: *Otero Co.*: 1 mi. S Cloudcroft, Sacramento Mts., 30.

E. canipes canipes, 13 adults, 2 bacula

TEXAS: *Culberson Co.*: The Bowl, Guadalupe Mts., 13 (10 TCRC).

E. canipes ssp., 5 adults, 3 bacula

NEW MEXICO: *Lincoln Co.*: 3 mi. S and 9 mi. W Corona, Red Cloud Canyon, Gallinas Mts., 2; 5 mi. N and 9 mi. E Capitan, Capitan Mts., 4.

E. cinereicollis, 60 adults, 38 bacula

ARIZONA: *Conconino Co.*: 7 mi. N Flagstaff, San Francisco Mts., 6; 9 mi. N Flagstaff at Fort Valley, San Francisco Mts., 2 AU; Doyles' Saddle, San Francisco Mts., 1 AU. *Apache Co.*: West Fork of the Black River, 8 AU; 25 mi. S Upper West Fork of the Black River, Springerville, 1 AU; 2 mi. E Phelps Ranger Station, White Mts., 1 AU; Escudilla Mt., 1 UI. *Greenlee Co.*: 4 mi. NE Hannagan Meadow, Blue Mts., 10 UI.

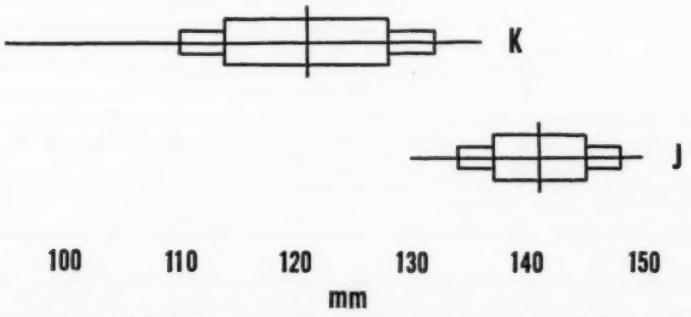


FIG. 5.—Head and body length of two populations of *Eutamias canipes.* J, *Eutamias canipes sacramentoensis,* 1 mi. S Cloudcroft, Otero Co., New Mexico (13 specimens). K, *Eutamias c. canipes,* The Bowl, Guadalupe Mts., Culberson Co., Texas (13 specimens).

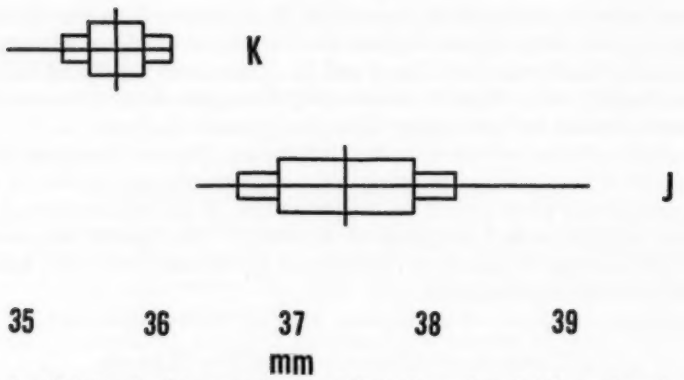


FIG. 6.—Skull length of two populations of *Eutamias canipes*; J (13 specimens) and K (10 specimens) from same localities as in Fig. 5.

NEW MEXICO: *Grant Co.*: 15 mi. E and 6 mi. N Santa Rita, Iron Canyon, Black Range, 28. *Catron Co.*: 10 mi. E Mogollon, Willow Creek, Mogollon Mts., 30. *Socorro Co.*: 11 mi. S and 3½ mi. E Magdalena, 1½ mi. E South Baldy, Magdalena Mts., 3; Mt. Withington, San Mateo Mts., 10.

E. bulleri durangae, 5 adults, 3 bacula

DURANGO: 3 to 9 mi. SW Las Adjuntas, 6 KU.

E. bulleri solivagus, 3 adults, 0 bacula

COAHUILA: 12 and 13 mi. E San Antonio de las Alazanas, 5 KU.

SUMMARY

1. The chipmunks heretofore known as *Eutamias cinereicollis canipes* are shown to differ as much from populations of *E. cinereicollis* west of the Rio Grande as the latter do from other species of chipmunks such as *E. quadrivittatus*. It is proposed that *E. c. canipes* be recognized as a distinct species to which the name *Eutamias canipes* Bailey should apply.

2. *Eutamias canipes* is represented by at least two subspecies. *Eutamis c. sacramentoensis* is found in the Sacramento Mountains, Otero Co., New Mexico, and *Eutamias c. canipes* is found just south of the New Mexican state line in the Guadalupe Mountains, Culberson Co., Texas. Chipmunks of this species in the Gallinas and Capitan Mountains seem distinctive but are not assigned to a named subspecies in this study.

LITERATURE CITED

BAILEY, VERNON. 1931. Mammals of New Mexico. N. Amer. Fauna, 53: 412 pp.

BENSON, SETH B. 1933. Concealing coloration among some desert rodents of the southwestern United States. Univ. Calif. Publ. Zool., 40: 1–69.

COCKRUM, E. LENDELL. 1955. Laboratory manual of mammalogy. Burgess Pub. Co., Minneapolis. 160 pp.

HOWELL, ARTHUR H. 1929. Revision of the American chipmunks. N. Amer. Fauna 52: 157 pp.

WHITE, JOHN A. 1953*a*. Taxonomy of the chipmunks *Eutamias quadrivittatus* and *Eutamias umbrinus*. Univ. Kansas Publ., Mus. Nat. Hist., 5 (33): 563–582.

———. 1953*b*. The baculum in the chipmunks of western North America. Univ. Kansas Publ., Mus. Nat. Hist., 5 (33): 611–631.

Dept. of Biology, Univ. of New Mexico, Albuquerque. *Received 16 February 1959.*

THE ORIGIN AND HOMOLOGY OF THE MALE REPRODUCTIVE SYSTEM IN *THOMOMYS BOTTAE*

By W. C. Gunther

The origin and homologies of the male reproductive system have been reported between and within several widely different groups of vertebrates. For the pocket gopher, however, the only description available to me was included in a morphological study of the adult system by Hill (1937). While working on the seasonal and experimentally produced variations of the reproductive system of the pocket gopher, I discovered (1956, 1957) several inconsistencies in the extant descriptions of the male system and found it necessary to attempt to establish homologies. At that time, on the basis of an incomplete series of embryos, only tentative designations were made and homologies were merely suggested. Now, with a complete series of pocket gopher embryos, it is my purpose to give a detailed description of the origin and homologies of the male reproductive system of the pocket gopher, *Thomomys bottae*.

MATERIALS AND METHODS

The reproductive systems of four male pocket gophers presumed to be in breeding condition were carefully dissected, embedded in paraffin, sectioned at 20 microns, and stained in Ehrlich's hematoxylin and eosin. Evidence that these males were in breeding condition was obtained by finely hashing portions of the epididymis in physiological saline and observing the many motile spermia in this suspension.

A closely spaced series of 54 embryos, ranging from 4–33 mm. crown-rump length, was likewise embedded in paraffin, sectioned at 20 microns, and stained in Ehrlich's hematoxylin alone, or in Ehrlich's hematoxylin and eosin. Of these, 31 were females, 18 males, and 5 were in the indifferent stage. Since nothing is known of the age-size relationships in pocket gopher embryos, such data are expressed as crown-rump length in millimeters.

RESULTS

Gross morphology of the adult male reproductive system.—The reproductive system as reported here is composed of two testes, two bulbo-urethral glands, two seminal vesicles, two coagulating glands, and one dorsal and two lateral prostate glands (Fig. 1). A detailed description of the development and homology of the penis, and of the origin of the germ cells, will not be given in this report. The urethra is of special interest only in connection with a common ejaculatory duct described below. Since some confusion might arise in the use of the word "urethra" this report will restrict its meaning to include only the tube (or portions thereof), together with its lining epithelium, leading from the bladder to the penis. The term "urogenital tract" will be used when the connective tissue and muscle surrounding the urethra and all contained ducts, as well as the urethra itself, are included in a description.

Microscopic morphology of the adult male reproductive system.—An examination of the cross-sections of the adult reproductive tract was made by Gunther (1956), and the histology of the prostate and coagulating glands, the seminal vesicles and the testes was described. The following information on the ducts of the secondary reproductive structures was not included in that report.

The duct of each seminal vesicle enters the dorsal portion of the vas deferens immediately preceding the entrance of the vas deferens into the urogenital tract. As the two vasa enter the connective tissue at the cephalic portion of the tract, they converge toward the midline and continue caudad for a short distance, one vas deferens on each dorsolateral side of a common ejaculatory duct, and then open into this ejaculatory duct (Plate I, *A*, see discussion).

The common ejaculatory duct is a short tube which lies embedded in the dorsal portion of the urogenital tract along the anteroposterior axis. The cephalic portion of this common ejaculatory duct ends blindly in the anterior portion of the urogenital tract. The posterior portion of the duct continues caudad to join the urethra, its entrance guarded by a muscular valve-like fold (Plate I, *B*). The urethra, after it enters the urogenital tract from the bladder, lies ventral to the common duct and parallels it for its entire length, ending blindly about a millimeter anterior to the ending of the common duct. Posteriorly the urethra continues into the penis. The urethra is lined with a

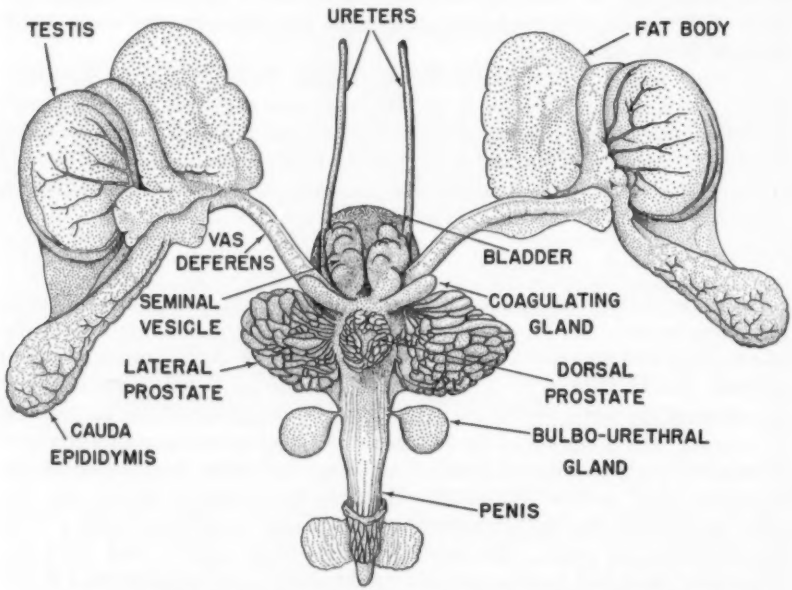


FIG 1.—Reproductive system of adult male pocket gopher, dorsal view (×2).

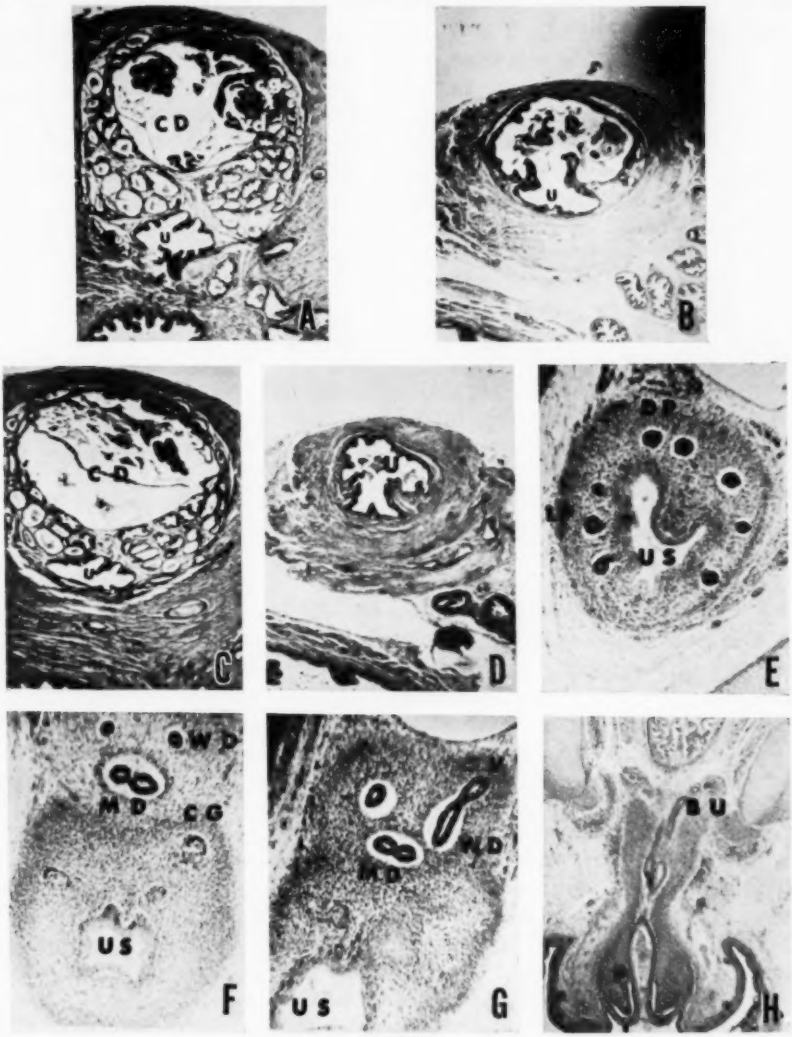


PLATE I

Sections through reproductive tracts of *Thomomys bottae*. *A–D*, adults, × 70; *E*, *G*, 31-mm. embryos, × 130; *F*, 28-mm. embryo, × 130; *H*, 28-mm. embryo, × 70. See detailed legends opposite.

A–D, sections through male urogenital tract at different levels; *E–G*, sections through urogenital sinus; *H*, section through penis. Symbols are as follows: B, bladder; BU, bulbo-urethral gland; CD, common ejaculatory duct; CG, coagulating glands; DP, dorsal prostate gland; LP, lateral prostate gland; MD, Müllerian duct; P, penis; SV, seminal vesicles; U, urethra; US, urogenital sinus; VD, vasa deferentia; WD, Wolffian duct.

transitional epithelium until it enters the penis, where the epithelium changes to stratified and pseudostratified columnar. The common ejaculatory duct is lined with a simple or pseudostratified columnar epithelium, but in the region of its junction with the urethra this changes to transitional.

The ducts from the coagulating gland are dorsal to the ducts of the seminal vesicles at the anterior portion of the urogenital tract. As the ducts of the coagulating gland course caudad they shift to a lateral position. Shortly after the vasa enter the common ejaculatory duct (Plate I, *A*), the coagulating gland ducts likewise enter the common duct.

The ducts of the dorsal prostate enter the dorsal portion of the common duct, and the ducts of the lateral prostate open into the lateral walls of the common ejaculatory duct (Plate I, *C*). Several ducts of the lateral prostate enter the urethra directly (Plate I, *C*, *D*).

Development of the testes.—The gonadal primordium at an early indifferent stage (4 mm. embryo) may be distinguished from the more dorsal portions of the urogenital ridge as a somewhat thickened band, bulging slightly into the abdominal cavity.

In the 5 mm. embryo the indifferent gonad is easily recognized as a ventrally projecting, loosely arranged epithelial mass connected by a broad base to the urogenital ridge. Within this blastema is a loosely arranged medulla and an outer and more densely packed cortex, the latter apparently being formed from the cells of the peritoneal epithelium with which it is in contact. The cortex is distinguished from the peritoneum in that it has several cell layers, while the thickness of the peritoneum is but a single cell. Mesonephric tubules (future rete testis) project into the blastema and in some cases almost fill its cavity completely except for the dense cortical layers. Consequently, it is believed that the somatic cells comprising the medulla are of mesonephric origin. The tunica albuginea separates the medullary from the cortical components of the gonad and is composed of a faint layer of mesenchymal cells.

At the 8 mm. stage the base of the gonad narrows and the gland is suspended in the abdominal cavity by a narrow mesorchium. Cells recognizable as germ cells appear to have become concentrated in the medulla, and some have become surrounded by the soma cells, giving the appearance of very early testis cords (primitve tubules of Witschi?). It is not clear from this material whether the cortex participates in the formation of these early tubules. At this time the cortex is very thin and a layer of peritoneal cells has separated from the cortex peripherally, although no distinct basement membrane lies between the cortex and the peritoneum. The tunica albuginea is somewhat thicker and, with the regression of the cortex, has come to lie closer to the periphery of the gonad.

The earliest recognizable definitive testis in this group of embryos occurred at 9 mm. The germ cells had become incorporated in six prominent solid tubules in one specimen. However, the number of tubules varied in different embryos. The cells comprising the walls of the tubules were traced in earlier embryos to the soma cells of the medulla (although one cannot exclude the

possibility that cortical cells participated). The cortex had completely regressed. The albuginea was considerably thicker and separated from the overlying peritoneum by a definite basement membrane. A distinct rete testis had differentiated from the mesonephric tubules, extending into the base of the gonad as several tubules with hollow lumina.

From the 9 mm. stage to birth (variable from 32–38 mm.) progressive differentiation of the testes is marked principally by the proliferation of additional cords organized by the medullary cells, the further incorporation of mesonephric tubules into the rete testis, the rapid formation of interstitial cells from the medullary cells, and the growth of testicular septula which seem to organize from the general mesenchymal bed of the medulla.

Development of the lateral and dorsal prostate glands.—The anlagen of these glands are first seen in the 23–24 mm. embryos as small solid cords of endoderm cells lateral and dorsal to the urogenital sinus (Plate I, *E*). In older embryos the cords become more numerous, and in 31 mm. stages (at or near birth) some of the cords acquire a lumen and communicate with the sinus. From the time the cords are first seen their walls are rarely more than several cells thick. The distal ends of the cords are knob-like, comprised of many cells. Further differentiation occurs during postnatal stages.

Development of the coagulating glands.—These appear first in the 23–24 mm. embryo. It is frequently difficult to distinguish them from dorsal prostate primordia. However, by observing carefully each dorsolateral corner of the urogenital sinus, the coagulating glands are apparent as a pair of solid streak-like cords of endoderm cells extending dorsally at a position near the fusion of the Müllerian ducts (Plate I, *F*). At the 31 mm. stage these cords have become hollow, and they communicate with the dorsolateral portions of the urogenital sinus. Like the prostate gland primordia, the walls of the coagulating glands at this stage are only a few cells thick and their distal ends are knob-like, comprised of many cells. Further differentiation occurs after birth.

Development of the seminal vesicles.—The paired seminal vesicles develop from the dorsal portion of each Wolffian duct in embryos of 24 mm. (Plate I, *G*). At this stage they are simply a shallow pocket. In older embryos the vesicles extend dorsad and craniad to the Wolffian duct, forming a definite lobe. The constricted neck of each lobe enters the Wolffian duct several hundred microns craniad to the latter's entrance into the urogenital sinus. The walls of the diverticulum are one cell thick, and no evidence of the lobulation characteristic of the mature gland is present.

Development of the bulbo-urethral glands.—These glands appear in embryos of 23–24 mm. They form adjacent to the future bulbus urethrae (Plate I, *H*) from the endodermal lining of the urogenital sinus as lateral cordal outgrowths. In stages just before birth the cords become hollow and communicate with the urethra near the latter's entrance into the penis. The distal end of each gland flares laterally like a scroll and the cells are numerous in this area. No further differentiation of the gland occurs until after birth.

In the adult the bulbo-urethral gland on each side enters the lateral portion of the urethra in the position indicated in Fig. 1. Histologically these glands are of the typical mammalian, compound tubulo-alveolar variety. The secretory cells vary from cuboidal to high columnar, depending on their functional state, and in hematoxylin-eosin preparations the cytoplasm stains very darkly, with prominent coarse granular inclusions. Secretions in the lumina of the alveola are brightly stained with eosin, are stringy, and often are precipitated into a network. Pseudostratified epithelium typical of the urethra at this point lines the execretory ducts.

DISCUSSION

The embryos described herein clearly demonstrate the origin and homologies of the male reproductive system of this pocket gopher.

The bulbo-urethral glands originate from the same kind of primordium as do those in other mammals. No peculiarities of origin or structure were noted.

The description of the development of the testes in this report is at variance with many classical studies by mammalian embryologists. For instance, Arey (1954) states, "the testis cords . . . perhaps arose . . . from the germinal epithelium, but this relation is not clear. At seven weeks they seem to organize suddenly within the blastemal mass. The radially arranged testis cords converge toward the mesorchium where a dense portion of the blastemal mass is also emerging as the primordium of the rete testis." Nothing, however, has been found in pocket gopher embryos which corresponds to a germinal epithelium. Furthermore, the rete testis organizes from the mesonephric tubules, and in fact the entire medulla appears to have been formed from the mesonephros. Consequently, the blastemal mass is not derived by proliferative ingrowth from the germinal epithelium as is so often stated.

In general, the results from the study of the pocket gopher may be interpreted as agreeing with the conclusions of Witschi (1956) as concerns testicular development in other mammals. There are some differences, however, particularly with reference to the disposition of the tunica albuginea and the fate of the cortical elements. The study of the gopher material does not indicate that the albuginea participates in locating itself under the peritoneum by growing between the cortical cylinders, or even that there are cortical cylinders, as Witschi has described. Rather, the cortical elements simply regress completely and the growth of the medullary tubules displaces the albuginea to its final position dorsal, and in direct apposition, to the peritoneum. It is also impossible to determine from the gopher material whether a gonial (germ) cell at early stages multiplies within the confines of a follicle cell and whether later the follicle cell is transformed into the Sertoli cell, as seen in Witschi's material. It is evident that the Sertoli cells are present as discrete entities and never enclose a number of dividing gonial cells. It is true that in the 8 mm. stage a germ cell is sometimes surrounded by a number of soma cells, but there is no evidence to indicate that one of the soma cells differentiates into a cyst and encloses the spermatogonium.

Hill (1937) mentions the prostate as a "paired structure." Actually, the dorsal and lateral prostate glands of the adult are three distinct bodies, each originating from the dorsal and lateral margins of the urogenital sinus, respectively. The lateral prostate of the gopher may be considered homologous with the middle prostate of the rat (Price, 1936).

The coagulating glands originate from the dorso-lateral corners of the urogenital sinus, and are therefore homologous with the coagulating glands of the guinea pig (Engle, 1926) and rat (Price, 1936). In adult gophers these are two club-shaped bodies. Hill (1937) stated there was "no specialized coagulating gland as in certain other rodents."

The seminal vesicles arise as evaginations of the mesonephric ducts and may be considered homologous with those in man (Watson, 1918) and the rat (Price, 1936). These were originally reported in the gopher by Hill (1937) as consisting of a "main, medial tubular lobe . . . and one (or several) smaller club-shaped lobes lateral to this." Apparently he included the coagulating gland in this description. In adult males the seminal vesicles are two quite distinct square structures, with one to several lobules to each gland.

The common ejaculatory duct apparently is formed only after birth from the still undifferentiated urogenital sinus. It was never present in any of the embryos examined. This duct, in the adult male in breeding condition, receives the ducts of the prostate and coagulating glands and the vasa deferentia. The counterpart of this structure in other mammals has not come to the author's attention. The common ejaculatory duct is not the urethra, since the common duct plainly enters a structure identified as the urethra. The common duct is lined with the same kind of epithelium as the separate ejaculatory ducts in man.

The urethra is peculiar since, in the adult, it does not form a straight tube leading from the bladder to the penis. Rather, after leaving the bladder and piercing the walls of the anterior portion of the urogenital tract, it bifurcates into a short blind anterior arm and a longer posterior arm, continuing posteriorly as the prostatic urethra, which in turn continues caudad as the membranous and cavernous portions of the urethra. These relations are not seen in the embryo.

ACKNOWLEDGMENTS

This investigation was supported in part by the Department of Zoology, University of California, Davis, and by a research grant from Valparaiso University, Valparaiso, Indiana. A portion of this paper was presented at the Fall Meeting, 1957, of the Indiana Academy of Science.

SUMMARY

1. The reproductive tracts of 4 adult male pocket gophers and 54 entire gopher embryos were embedded in paraffin, sectioned, and stained in order to trace origins and homologies.

2. The testes, coagulating glands, one dorsal and two lateral prostate glands, two seminal vesicles, and two bulbo-urethral glands were found to be homologous with those in other mammals.

3. The development of the primary and secondary sexual organs was traced, and the origin of the testicular primordia was discussed.
4. A common ejaculatory duct and a peculiar kind of urethra, heretofore unknown, were described.

LITERATURE CITED

AREY, L. B. 1954. Developmental anatomy. W. B. Saunders Company, Philadelphia. 680 pp.

ENGLE, EARL T. 1926. The copulation plug and the accessory genital glands of mammals. Jour. Mamm., 7: 119–126.

GUNTHER, W. C. 1956. Studies on the male reproductive system of the California pocket gopher (*Thomomys bottae navus*, Merriam). Amer. Midl. Nat., 55: 1–40.

———. 1957. Some dietary effects on the estrous cycle of the female California pocket gopher (*Thomomys bottae navus*, Merriam). Proc. Ind. Acad. Sci., 66: 331–336.

HILL, JOHN E. 1937. Morphology of the pocket gopher mammalian genus *Thomomys*. Univ. Calif. Publ. Zool., 42: 81–172.

PRICE, DOROTHY. 1936. Normal development of the prostate and seminal vesicles of the rat with a study of experimental postnatal modifications. Amer. Jour. Anat., 60: 79–127.

WATSON, E. M. 1918. The development of the seminal vesicles of man. Amer. Jour. Anat., 24: 395–442.

WITSCHI, E. 1956. Development of vertebrates. W. B. Saunders Company, Philadelphia. 588 pp.

Dept. of Biology, Valparaiso Univ., Valparaiso, Indiana. *Received 12 November 1958.*

ALASKAN RECORDS OF THE NARWHAL

BY OTTO WILLIAM GEIST, JOHN L. BUCKLEY AND RICHARD H. MANVILLE

The occasional occurrence of the narwhal, *Monodon monoceros*, in Alaskan waters has been recognized at least since 1874. Since that time a number of authors have commented on its occurrence, with most remarks centered around the area east of Point Barrow (Scammon, 1874: 107; Ray and Murdoch, 1885: 100; Turner, 1886: 199; Nelson and True, 1887: 290; Murdoch, 1898: 728; MacFarlane, 1905: 731; Dufresne, 1946: 195; Anderson, 1947: 87; and Bee and Hall, 1956: 159). The only specimen record of which we are aware (San Diego Society of Natural History, complete skull and tusk, No. 7096, collected by an Eskimo near Cape Halkett, Harrison Bay, at the mouth of the Colville River, Lat. 71° N, Long. 151° W, during the summer of 1928) was published by Huey (1952: 496).

We wish to report three additional records and observations. The first of these is a specimen at the University of Alaska, complete skeleton and tusk, No. 3380. This specimen was found on the beach of Kiwalik Bay (Lat. 66° N,

Long. 162° W) on 14 August 1957, by George Moto, an Eskimo resident of Candle, Alaska, who reported his discovery as follows:

> My description of this unidentified whale will be as close as I can describe. First the tusk, or sword, which-ever it may be named, is 33 inches long, approximately 2 inches in diameter at the base, tip about ¼ inch and had a left hand twist (which is ivory or bone?).
>
> The head is flat at the nose, that is up and down, small mouth and toothless, unless the teeth had fallen out from deteration. Naturally a pair of eyes, has a blower as a whale.
>
> Body measurements from head to tail, 13 ft. 6 in., back black, bottom white, tail flat and small so are the flippers. The body tapers sharply, from about two feet to 8 in.

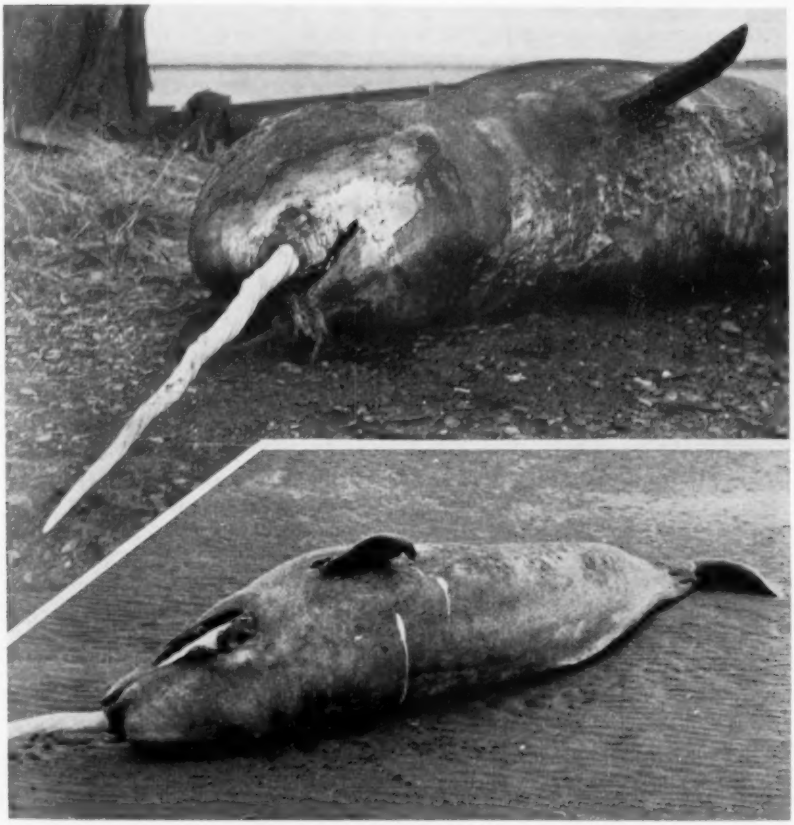


PLATE I

Narwhals stranded in Alaska. TOP: On beach at Kiwalik, August 1957; photo by Otto William Geist. BOTTOM: In Nelson Lagoon, April 1957; photo by Doris Cowden.

On 20 August the senior author obtained the following measurements: Length, from nose to notch of flukes, 13 ft. 4½ in.; length, from tip of tusk to notch in flukes, 16 ft. 3 in.; maximum girth, about 6 ft. 8 in. In fleshing the skeleton for shipment, the tip of another narwhal tusk 4⅞ inches long was found embedded in the left upper jaw of this animal. The piece of broken tusk was apparently partly surrounded by a thin bony exostosis, which indicates that it had been present for some time. Porsild's (1922) report discusses the broken tusks of narwhals, and the occasional plugging of the tip of a broken tusk with the broken tip of another. However, we are aware of no previous record of a tusk fragment embedded in any part of the animal other than the tusk. We consider the tusk fragment as possible evidence of fighting among males.

The body of the narwhal was badly bruised, possibly from pounding by the surf. Plate I (top) shows the specimen on the beach at Kiwalik.

Our second record is supported by a photograph (Plate I, bottom) taken in April 1957. This narwhal was reported to us by Mrs. Doris Cowden of Port Moller, Alaska. It was found, still alive, by Bill Johnson on 20 April 1957, at the mouth of the Caribou River in Nelson Lagoon (Lat. 56° N, Long. 161° W) on the Alaska Peninsula. The animal was stranded in a few inches of water and was thrashing violently. Bald eagles and gulls were already feeding on it, so Johnson shot it. There were no other wounds on the body. The total length was estimated to be about 14 feet, and the tusk an additional 7 feet. The carcass was washed away, and no part of the specimen was recovered.

A third record was provided to us by Robert L. Rausch, who found a section of tusk 385 mm. long by 40 mm. in diameter on the beach at Wainwright, Alaska. Rausch is still in possession of this tusk fragment.

Murie (1936: 346) reports that a single tusk was found on a sandbar at Cape Chibukak, St. Lawrence Island, "some years ago." Ivar Skarland (*in litt.*) of the University of Alaska recalls having seen, in 1937, a harpoon foreshaft receiver made of narwhal tusk. This implement was purchased in Kotzebue and showed evidence of some use. Skarland also reports that he has seen a number of small harpoons, for the tourist trade, carved from ivory and bone with twists imitating those on a narwhal tusk. It is his belief that little narwhal ivory has been found in Alaska and that most that is here was acquired by trade from the Eskimos of Canada well to the east of Alaska.

In summary, our specimen from Kiwalik is several hundred miles south and west of other specimen records, and our record of a live animal on the Alaska Peninsula extends the known range of the narwhal to the southern side of the Bering Sea several hundred miles south of the specimen records.

LITERATURE CITED

Anderson, R. M. 1947. Catalogue of Canadian Recent mammals. Bull. Natl. Mus. Canada, Biol. Ser., No. 31: vi + 238.

Bee, James W. and E. Raymond Hall. 1956. Mammals of northern Alaska on the Arctic slope. Univ. Kansas Mus. Nat. Hist., Misc. Publ. No. 8: 1–309.

DUFRESNE, FRANK. 1946. Alaska's animals and fishes. New York: A. S. Barnes. xviii + 297 pp.

HUEY, LAURENCE M. 1952. An Alaskan record of the narwhal. Jour. Mamm., 33: 496.

MACFARLANE, R. 1905. Notes on mammals collected and observed in the northern Mackenzie River District, Northwest Territories of Canada. Proc. U. S. Natl. Mus., 28: 673–764.

MURDOCH, J. 1898. The animals known to the Eskimos of Northwestern Alaska. Amer. Nat., 32: 719–734.

MURIE, OLAUS J. 1936. Notes on the mammals of St. Lawrence Island, Alaska. *In* Archaeological Excavations at Kukulik, St. Lawrence Island, Alaska. Univ. Alaska, Misc. Publ., 2: 337–346.

NELSON, E. W. AND F. W. TRUE. 1887. Mammals of northern Alaska. Pt. 2 *in* Report upon natural history collections made in Alaska between the years 1877 and 1881 by Edward W. Nelson. Arctic Publ. No. 3, Signal Service, U. S. Army; pp. 227–293.

PORSILD, MORTON P. 1922. Scattered observations on narwhals. Jour. Mamm., 3: 8–13.

RAY, P. H. AND J. MURDOCH. 1885. Report of the International Polar Expedition to Point Barrow, Alaska. Washington, 695 pp.

SCAMMON, CHARLES M. 1874. The marine mammals of the northwestern coast of North America, described and illustrated: together with an account of the American whale fishery. New York: G. P. Putnam's Sons. 319 pp.

TURNER, L. M. 1886. Contributions to the natural history of Alaska; results of investigations made chiefly in the Yukon District and the Aleutian Islands. Arctic Publ. No. 2, Signal Service, U. S. Army; pp. 1–226.

Univ. of Alaska, College, and Bureau of Sport Fisheries and Wildlife, Washington, D. C. Received 23 March 1959.

MAMMALS OF RIPLEY AND JEFFERSON COUNTIES, INDIANA

BY DWIGHT M. LINDSAY

Published records of mammals collected in Indiana since the time of Lyon (1936) are few. In 1948, Kirkpatrick and Conaway listed 37 species from various counties of the state. Cope and Mumford (1955) wrote concerning bat banding in the state. Mumford and Handley (1956) published records of 30 species in Jackson County. Since I have previously published (1956*a*, *b*) specific accounts of the bats of southeastern Indiana, they are not included in the present paper. In 1952, I began collecting mammals in the southeastern portion of the state. Although the need for a statewide study was evident, time limited the present study to Ripley and Jefferson Counties. These counties were selected for two reasons: first, there was a paucity of records and specimens from this area and, second, the area was convenient for collecting purposes. The major objective of the study was to collect and identify the species

present in a particular region and preserve specimens for the use of future students. Particular attention was given to establishing the taxonomic status of critical subspecies.

Most specimens were taken with ordinary snap-traps baited with rolled oats and peanut butter. Bats were collected by hand in caves and with shotgun at dusk. The larger specimens were collected by various techniques, some caught in rat-size snap-traps, others obtained from hunters and trappers, while some were found dead along highways. Museum skins and skulls were prepared of all specimens, and are deposited at the University of Kentucky, the University of Cincinnati, and the U. S. National Museum.

The most outstanding physiographic feature of the area studied is the extensive very low relief known as the "flats", distinctly different from other regions of the state (Barnes, 1952). Ripley and Jefferson Counties lie within the area of Illinoian glaciation, a division of the Western Mesophytic Forest Region (Braun, 1950). The edaphic factors characteristic of the "flats" favor development of hydromesophytic forest communities. Pin oak (*Quercus palustris*), red maple (*Acer rubrum*), sweet gum (*Liquidambar styraciflua*), white elm (*Ulmus americana*), swamp white oak (*Q. bicolor*), white oak (*Q. alba*), sour gum (*Nyssa sylvatica*), shellbark hickory (*Carya ovata*) and beech (*Fagus grandifolia*) comprise the dominant tree species.

SPECIES ACCOUNTS

In the following annotated list all measurements are in millimeters; averages are given first and extremes in parentheses.

Didelphis marsupialis virginiana Kerr. Opossum.—This is a common species in both Ripley and Jefferson Counties as evidenced by collection of several skulls and observation of a dozen road kills. An adult male, which may be of nearly record size for the species, was found asleep in the hollow base of a sour gum tree. Its measurements were: Total length, 788; tail (partly missing), 241; hind foot, 80; skull length, 141; skull width, 76.3; weight, 5.4 kg.

Sorex cinereus ohionensis Bole and Moulthrop. Masked shrew.—Twelve *Sorex cinereus* were collected, all near Rexville, Ripley County. Average body measurements are: Total length, 87.6 (83–92); tail, 31.2 (29–34); hind foot, 11.5 (11–13). Cranial measurements are given in Table 1. Average weight of nine specimens is 3.4 (2.2–5.1) grams. Two females taken 5 April 1955 appeared to be lactating. Jackson (1928), Lyon (1936) and Hamilton (1943) considered Indiana to be inhabited by the nominate race, *S. c. cinereus*, while Bole and Moulthrop (1942) and Hall and Kelson (1959) consider *S. c. lesueurii* the subspecies present within the state. However, apparently specimens of this species have never been collected in the southern two-thirds of Indiana, except for two counties in the extreme southwestern portion. In size, the specimens collected in the present study are considerably smaller than typical *S. c. cinereus*. Upon comparing specimens collected in this study with specimens of *S. c. ohionensis*, C. O. Handley, Jr., found the two to be identical. The present specimens are therefore recorded as the Ohio race of *S. cinereus*. This subspecies has not been reported in Indiana previously.

Nine of these shrews were caught in runways in the leaf mold along the edge of a well-rotted white oak log in a hydro-mesophytic forest where the larger trees had been cut. The remaining specimens were trapped in grassy surface runways along the edge of this forest.

Sorex longirostris longirostris Bachman. Southeastern shrew.—On 11 April 1955, J. Dan Webster found a lactating female of this species dead on the Hanover College campus, in

Jefferson County. The skin and skull were later deposited in the California Academy of Sciences where the specimen was identified by Robert T. Orr. Body measurements are: Total length, 86; tail, 28; hind foot, 10. Cranial measurements are: Condylobasal length, 14.2; palatal length, 5.4; cranial breadth, 7.4; interorbital breadth, 2.8; maxillary breadth at M_3, 3.9; maxillary tooth row, 5.0. *Sorex longirostris* is rarely found in collections. Jackson (1928) found only 24 specimens among 10,293 of the genus *Sorex*. Three of the 24 were from Bicknell, Knox County, Indiana, and are apparently the only known specimens of this shrew from the entire state. The Hanover College specimen extends the known range of Bachman's shrew eastward across most of southern Indiana. The fact that this specimen was found immediately adjacent to a rugged, dissected region that contains one of the most primitive habitats to be found in the state may be of significance. Hanover College (founded in 1827) purchased much of the land adjacent to the campus and the region has remained much as it was before the advent of the white man.

TABLE 1.—*Cranial measurements (in millimeters) of Sorex cinereus*•

NUMBER	SEX	CONDYLOBASAL LENGTH	PALATAL LENGTH	CRANIAL BREADTH	INTERORBITAL BREADTH	MAXILLARY BREADTH	MAXILLARY TOOTH ROW	3RD AND 4TH UNICUSPIDS	TOOTH WEAR
179	—	14.2	5.7	7.2	2.6	3.5	5.2	3=4	much worn
1316	—	15.0	6.1	7.5	2.6	3.7	5.6	3=4	worn
457	♀	14.7	6.0	7.3	2.7	3.5	5.5	3>4	worn
458	♀	14.5	5.7	7.2	2.6	3.5	5.3	3=4	worn
460	♂	14.7	5.7	7.3	2.6	3.6	5.3	3<4	much worn
459	♂	14.7	6.0	7.5	2.7	3.5	5.5	3=4	worn
1315	—	—	5.8	7.6	—	—	5.2	3=4	—
1314	♀	14.4	5.7	7.2	2.4	3.5	5.3	3>4	worn
789	♂	14.3	5.7	7.2	2.6	3.7	5.3	3<4	unworn

• All measurements by C. O. Handley, Jr.

Blarina brevicauda kirtlandi Bole and Moulthrop. Short-tailed shrew.—Eighteen *Blarina* were taken in Ripley County and ten in Jefferson County. Average measurements of 27 specimens are: Total length, 110.1 (103–122); tail, 23.4 (20–26); hind foot, 14.6 (13–16). Cranial measurements of 20 individuals are: Length, 21.2 (20.3–22.0); breadth, 11.9 (11.4–12.5). Weight of 22 specimens averages 14.1 (9.9–19.9) grams. A specimen taken 3 April 1954 appeared to be lactating. Most of the specimens were taken in wooded areas, some on the surface, others in underground runways. The remainder were trapped in runways in weed fields or in fence rows.

Lyon (1936) and Hamilton (1943) considered the northern two-thirds of Indiana to be inhabited by *B. b. brevicauda* and the southern third by *B. b. carolinensis*. All Indiana *Blarina* were assigned to the race *B. b. kirtlandi* by Bole and Moulthrop (1942). Mumford and Handley (1956) recorded *B. b. kirtlandi* from Jackson County and considered material to the north to be of that race but they considered all *Blarina* from the counties bordering the Ohio River (including Jefferson County) as belonging to the race *B. b. carolinensis*. They recognized, however, that those from the southeastern portion of the state trend toward *B. b. kirtlandi*. In December 1957, Handley (*in litt.*) revised this determination as follows:

> In the light of new material from Ripley, Scott and Jefferson Counties, this opinion must be altered. Until more material is secured in extreme SW Indiana, I would continue to regard the Cypress Junction (Vanderburgh County) specimen as *carolinensis*. All other southern Indiana material I would refer to *kirtlandi*. Specimens from the northern part of the state perhaps trend toward *brevicauda*.

Cryptotis parva parva (Say). Least shrew.—Twenty-six *Cryptotis* were taken, three from Jefferson County, the remainder from Ripley County. Average measurements are: Total length, 77.1 (72–84); tail, 16.3 (14–20); hind foot, 11.2 (10–12). Cranial measurements of nine specimens are: Length, 15.6 (15.0–15.9); breadth, 7.9 (7.7–8.1). Average weight of ten individuals is 4.3 (3.6–5.0) grams. A majority of the specimens were taken from grassy runways in weed fields which had not been under cultivatioin for two or three years. One individual was found dead in the middle of a harvested lespedeza field. The skull was crushed but no tooth marks were apparent.

On a fill at the edge of a farm pond two adult *Cryptotis* were found occupying a nest under a board. The nest, located in a cup-shaped depression in the soil, was approximately 4 inches in diameter and 2½ inches in depth. It was constructed of dried grasses and had two entrances, one at the top and the other at the bottom. A short tunnel in the soil led to the bottom entrance.

Lyon (1936) did not recognize subspecific differences in this species, while Hamilton (1943) considered Indiana as well as adjoining states to be inhabited by the subspecies *C. p. parva*. Bole and Moulthrop (1942) considered Indiana as inhabited by the subspecies *harlani*. Apparently Kirkpatrick and Conaway (1948) follow the latter classification, since they record *harlani* from Ripley, Dearborn, Carroll and Tippecanoe Counties. As specimens in the present collection were compared at the U. S. National Museum with topotypes of *C. p. parva* and found indistinguishable, they are so recorded in this work.

Scalopus aquaticus machrinus (Rafinesque). Prairie mole.—Two prairie moles were collected from Jefferson County and one from Ripley County; all were taken from lawns. As evidenced by their surface tunnels, moles are found throughout the area under investigation but nowhere are they common. Their relative scarcity may be attributed to their preference for loamy or sandy soil, where burrowing is easier (Jackson, 1915), and to the infrequency of this type of soil in the Ripley and Jefferson County area. Not a single "molehill" was seen in the course of this investigation, although they had been observed previously in this area by the author.

Sylvilagus floridanus mearnsii (J. A. Allen). Eastern cottontail.—The cottontail is very common throughout the area, as evidenced by observations and road kills. Two specimens were collected, one from Jefferson County and one from Ripley County. They are assigned to *S. f. mearnsii on* geographical grounds.

Marmota monax monax (Linnaeus). Woodchuck.—According to Hahn (1909), woodchucks were rare in the Ohio County region in 1885. At that time most men in his locality were ignorant as to the identity of the animal, whereas at the time of his writing (1908) there were 25 to 50 "ground hogs" living on the farm where he was reared. The present writer recalls that approximately 25 years ago this animal was rare in the "flats" of Ripley County but was very common in dissected portions. Today woodchucks are found throughout the county, but most frequently in the dissected areas.

Tamias striatus ohionensis Bole and Moulthrop. Eastern chipmunk.—Three female and two male chipmunks were taken, three from Ripley County and two from Jefferson County. Average measurements are: Total length, 249.8 (241–267); tail, 91.4 (88–104); hind foot, 38.2 (38–40). The average weight of three specimens is 105.4 (105.3–105.6) grams. Cranial measurements of two specimens are: Length, 42.3 and 41.9; interorbital constriction, 12.3 and 11.9; zygomatic breadth, 23.9 and 23.1; nasal length, 15.0 and 14.3. At the U. S. National Museum these specimens were compared with specimens of *T. s. griseus* collected in Minnesota and were found to have less contrast in the dorsal pattern of hair color. Upon

comparison with specimens of *T. s. striatus* from North Carolina, they were found to be paler. Adequate material of *T. s. rufescens* was not available for comparison. On the strength of the above comparisons, and because of geographical distribution, the specimens in this series are recorded as *T. s. ohioensis*. According to Bole and Moulthrop (1942), the type locality for this race is Cincinnati, Hamilton County, Ohio—approximately 60 miles east of the area under investigation. Twenty years ago chipmunks were, for the most part, restricted to dissected areas. At present they occur in the "flats" as well as in dissected areas.

Sciurus carolinensis carolinensis Gmelin. Gray squirrel.—Three gray squirrels were taken, two from Ripley County and one from Jefferson County. This species is less common than the fox squirrel in most portions of the area. These specimens are assigned to the race *S. c carolinensis* for geographical reasons.

Sciurus niger rufiventer Geoffroy. Fox squirrel.—Two fox squirrels were taken in Jefferson County and one in Ripley County. They are assigned to the race *S. n. rufiventer* for geographical reasons. On several occasions both gray and fox squirrels were observed on highways, apparently licking something from the surface of the road. Perhaps salt, applied by highway maintenance crews to eliminate ice, remained on the surface in sufficient quantity to attract them.

Glaucomys volans volans (Linnaeus). Flying squirrel.—The flying squirrel is undoubtedly more common in the area than the few observations indicate. Much trapping was done, using snap-back rat traps nailed on beech trees and baited with raw beef or sweet corn. One lactating female was taken in Ripley County. Measurements are: Total length, 225; tail, 90; hind foot, 32; cranial length, 34.5; cranial breadth, 22.0. Weight was 73.7 grams. Since only a single specimen was taken and adequate material of the various races of this species is not available for comparison, this specimen is recorded as *G. v. volans* for geographical reasons.

Castor canadensis Kuhl. Beaver.—A beaver skull deposited at Hanover College has been lent to the author by J. Dan Webster, who relates the following account of its history:

> When he (Dr. Webster) came to Hanover College in 1949, his predecessor, the late Joseph L. Hyatt, called his attention to the beaver skull and stated that when he came to Hanover College in 1929, his predecessor, Leonhard L. Huber, said that the beaver skull was from a specimen which had been trapped by a farmer nearby and brought to his predecessor, Dr. Andrew H. Young. Dr. Young was professor of Biology and Chemistry at Hanover College from 1879 to 1926.

There is no date or locality inscribed upon the skull, so the above history cannot be substantiated, but the skull is obviously an old one. There are no native beavers in Indiana today; the date of their disappearance is unknown. It may be significant that Hanover College is only about 15 miles from the Scottsburg Marsh, which was drained about 1900 and may have been one of the last holdouts of native beavers in Indiana. If the skull deposited at Hanover College is that of a native beaver, it represents the most complete skull known in the state. Measurements are: Length, 124.0; breadth, 93.5; interorbital constriction, 25.1.

Peromyscus maniculatus bairdii (Hoy and Kennicott). Deer mouse.—Fifty-three deer mice were taken in Ripley County and 13 in Jefferson County. Average measurements are: Total length, 132.1 (116–153); tail, 51.2 (40–66); hind foot, 18.6 (17–22). Average weight of 42 specimens is 15.0 (10.6–19.3) grams. Cranial measurements of 47 specimens are: Length, 22.7 (21.0–25.0); breadth, 12.0 (10.8–13.0). Most of these specimens were taken in grassy runways of weed fields that had not been cultivated for several years. Others were trapped in fence rows between cultivated fields. Undoubtedly this species has become much more common in the state during the last hundred years as more and more land has been cleared. The first published record of its occurrence in the state was by

Osgood (1909). Lyon (1936) records specimens from 12 counties, and since that time Lyon (1942) and Kirkpatrick and Conaway (1948) have published records for two more counties. I have found this species almost as abundant as *Microtus*.

Nests of deer mice were observed in hollow fence posts and under piles of soybean hay. Pregnant females were trapped during the months of February, April and December, indicating some breeding throughout the year in Ripley and Jefferson Counties. Hamilton (1943) states that *P. maniculatus* breeds from early spring until late fall, except for a quiescent period during the middle of the summer. Burt (1954) states essentially the same for this species in Michigan.

Peromyscus leucopus noveboracensis (Fischer). White-footed mouse.—One hundred and six *P. leucopus* were collected in Ripley County and 17 in Jefferson County. Average measurements of 59 males are: Total length, 167.0 (148–194); tail, 76.8 (63–90); hind foot, 21.7 (20–23). Fifty-two females have these measurements: Total length, 165.8 (146–204); tail, 76.0 (58–98); hind foot, 21.9 (19–24). The average weight of 38 males is 20.8 (17.1–28.6) grams while 32 females average 19.9 (14.3–32.1) grams. Cranial measurements of 78 skulls of both sexes are: Length, 25.7 (24.1–27.8); breadth, 13.2 (12.1–14.3). These specimens were taken from a variety of habitats but never from an area without woody plants. Approximately 100 were trapped in mesophytic forests. Two of these were caught in snap-back rat traps nailed about 6 feet above ground on beech trees. Pregnant females were trapped during the months of February and April. It appears unusual that only three of 52 female *P. leucopus* were pregnant while six of 20 *P. maniculatus* contained embryos.

At the U. S. National Museum the adult pelages of this series were compared with specimens of *P. l. leucopus* from Louisiana and of *P. l. noveboracensis* from New York and Connecticut, and were found to be nearer the latter. In addition to pelage color, size is also a criterion in separating these races, *leucopus* being the smaller. Lyon (1936) gives 172 and 176 mm., respectively, as averages of total lengths of 10 adult males and 10 adult females (*noveboracensis*) collected in northern Indiana. Hamilton (1943) gives 170.5 mm. as the average total length of 30 adults of this race from eastern New York. The specimens in the present study, collected in southeastern Indiana, average 166.5 mm. in total length. Fifty-one specimens of *leucopus* taken by the author near Georgetown, Scott County, Kentucky, average 160.0 mm. in total length. Since the specimens taken in the present study are nearest *noveboracensis* in both pelage color and total length, they are considered to be *noveboracensis*.

A male taken on 31 December 1953 at the base of a beech tree is sufficiently different from the other specimens to merit special mention. This *Peromyscus* measures: Total length, 194; tail, 87; hind foot, 22. Weight is 28.6 grams. The total length of this specimen is 8 mm. greater and the weight is 2.9 grams more than any other male in the series. The pelage is quite distinct from the others in being uniformly lighter in color and having a "bleached" appearance. Upon examination of the skull it is evident that this mouse was quite senile when captured. All cusps of the molar teeth are worn away, causing the cutting surface to be flat. This is in contrast with younger adults in which the cusps are present, although somewhat worn.

Synaptomys cooperi cooperi Baird. Bog lemming.—One specimen was taken in Ripley County and 14 in Jefferson County. Average measurements are: Total length, 119.8 (106–135); tail, 19.4 (17–22); hind foot, 18.9 (17–20). Average weight of 13 specimens is 29.0 (19.9–39.6) grams. Cranial measurements of six specimens are: Length, 25.2 (24.7–26.1); breadth, 15.7 (15.0–16.2). Ten of the 15 specimens were taken in fescue and scattered, introduced weeds. Additional specimens were taken in runways through bluegrass in weed fields and in fence rows. Pregnant females were taken as follows: two on 5 March, one containing four 8-mm. embryos, the other two 17-mm. embryos; one on 17 March containing two 12-mm. embryos; one on 20 March containing three 13-mm.

embryos; and one on 27 December containing three 16-mm. embryos. A female taken 17 March appeared to be lactating.

According to Lyon (1936) and Hamilton (1943), Indiana is inhabitated by the race *S. c. stonei*. Bole and Moulthrop (1942) consider the southern portion of the state to be inhabited by a race they designate as *saturatus*. Kirkpatrick and Conaway (1948) record *saturatus* from Ripley County as well as other Indiana counties. Wetzel (1955) regards the race *saturatus* as invalid and considers the entire state to be inhabitated by the nominate race, *cooperi*. Mumford and Handley (1956) follow Wetzel in recording *cooperi* from Jackson County. Hall and Kelson (1959) consider most of Indiana, including the area under investigation, to be inhabited by the nominate race. After examination of the specimens collected in this study, Handley (*in litt.*, 1957) writes:

> A good series, including many adults, from Jefferson County, is clearly *S. c. cooperi*. Although averaging relatively large in external dimensions, these mice have skulls that are small and lack the heavy construction of those from SW and W Indiana referred to *S. c. gossii*.

Microtus pennsylvanicus pennsylvanicus (Ord). Meadow vole.—Six adults were taken in Ripley County and two in Jefferson County. Average measurements of eight adults, six of them females, are: Total length, 153.9 (140–167); tail, 39.4 (35–41); hind foot, 20.9 (20–22). Average weight of six is 35.6 (29.2–47.2) grams. Cranial measurements of four specimens are: Length, 26.8 (26.0–27.9); breadth, 14.7 (14.0–15.5). Most of the specimens were taken in weed fields not cultivated for several years. A few were taken in fence rows. Pregnant females were taken during April, October and December.

Microtus ochrogaster ochrogaster (Wagner). Prairie vole.—Forty-six prairie voles were taken in Ripley County and 19 in Jefferson County. Average measurements of 27 adult males are: Total length, 145.2 (131–166); tail, 35.3 (30–44); hind foot, 20.2 (19–22). Average weight of 26 males is 33.9 (23.6–43.8) grams. Thirty-one females have these measurements: Total length, 140.0 (122–166); tail, 33.4 (26–42); hind foot, 19.6 (17–22). Average weight of 24 females is 29.9 (21.1–42.2) grams. Cranial measurements of 31 specimens of both sexes are: Length, 25.2 (22.7–27.0); breadth, 14.6 (12.6–16.0). Pregnant females were taken during February, March, April, October and December. Apparently this species breeds throughout the year in this locality.

These mice were taken in a variety of habitats, the majority trapped in cultivated fields where considerable cover remained or in weed fields. The hair of the underparts of specimens in this series is buffy colored, but less pronounced than in a series of *M. o. ochrogaster* collected near Louisville, Jefferson County, Kentucky. However, since buffy-colored underparts are typical of *ochrogaster* and silver-gray underparts are the chief distinguishing characteristic of the race *ohionensis*, according to Bole and Moulthrop (1942), the specimens in this collection are considered to be *ochrogaster*.

Pitymys pinetorum auricularis (V. Bailey). Pine vole.—Twenty pine voles were taken, two from Jefferson County and the remainder from Ripley County. Five adult males average: Total length, 117.8 (111–124); tail, 21.2 (21–22); hind foot, 17.2 (17–18). Thirteen females have these measurements: Total length, 122.9 (113–131); tail, 21.3 (18–24); hind foot, 17.8 (16–19). Average weight of eight specimens of both sexes is 26.9 (21.5–30.7) grams. Measurements of skulls of 10 individuals of both sexes are: Length, 24.2 (23.0–25.4); breadth, 15.0 (13.5–16.0). A female containing two 20-mm. embryos was taken on 15 November 1952, and another containing two 18-mm. embryos was taken on 26 October 1952.

Undoubtedly the pine vole is much more common in Indiana than published records indicate. Only 18 counties have previous records of this species and, of these, one-half are sight records. Although chiefly a fossorial animal, most of the animals taken in this study were taken above ground. This is probably because most of the trapping was done above

ground in undissected regions of Ripley County where the water table is near the surface of the soil during much of the year. One specimen was taken from a surface runway in a thick cover of bluegrass. Two additional specimens were trapped in surface runways of a fence row between cultivated fields. Twelve specimens were trapped from surface runways in somewhat open areas within a hydro-mesophytic forest.

Early in the afternoon of 1 June 1955, along a road in a wooded region of a dissected area, distinct movements of fallen leaves were seen and noises heard resembling those of birds scratching in the fallen leaves. Upon investigation, small openings in the earth were found beneath these leaves. Each of these openings led downward to an underground passageway which ran parallel to the surface of the ground at a depth of 2–4 inches. Traps set across such runways caught five additional pine voles, in one case within 10 minutes after setting. Apparently pine voles were coming to the surface and feeding under the leaves.

According to Lyon (1936) *P. p. scalopsoides* inhabits the northern two-thirds of Indiana and *auricularis* the southern third. At the U. S. National Museum specimens of the present collection were compared with those of *auricularis* from Mississippi, Tennessee, western Kentucky and southwestern Indiana and were found to be nearly identical in pelage color and size. The entire dorsum of specimens of this race, especially the flank region, is darker in color that that of specimens of *scalopsoides* collected in the Washington, D. C., area. Moreover, the belly region is usually buffy in *auricularis* and grayish in *scalopsoides*. Thus Lyon's analysis of the distribution of the two races in Indiana is substantiated. Apparently Ripley County is near the northern limit of the range of *auricularis*, since Handley (1952) examined three specimens from Brookville, Indiana, approximately 40 miles north of the area under investigation and recorded them as *scalopsoides*. Also, Hall and Cockrum (1953) and Hall and Kelson (1959) consider Ripley County to be in the extreme northern limit of the range of *auricularis*.

Ondatra zibethicus zibethicus (Linnaeus). Muskrat.—Although common throughout the area wherever aquatic conditions are suitable, only one muskrat was taken in Ripley County. Three skulls were obtained from a trapper near Wirt, Jefferson County.

Rattus norvegicus (Berkenhout). Norway rat.—This is a common pest around farm buildings, in corn shocks, and in towns and cities. Two specimens were collected in Ripley County and one in Jefferson County.

Mus musculus Linnaeus. House mouse.—The house mouse is a common nuisance, not only around farm and city buildings but also in open fields. Numerous specimens were trapped, but only two were saved from Ripley County and one from Jefferson County.

Vulpes fulva (Desmarest). Red fox.—During the first 11 months of 1957 the Ripley County Auditor paid bounties on 243 foxes while the Jefferson County Auditor paid bounties on 239. Unfortunately, their offices do not keep records as to the relative abundance of the red fox and gray fox, but they are of the opinion that the red fox outnumbers the gray by about 10 to 1. These findings approximate those of Mumford and Handley (1956) in Jackson County.

Urocyon cinereoargenteus (Schreber). Gray fox.—Gray foxes are found in both Jefferson and Ripley Counties, as indicated by bounty records, but are much less common than red foxes.

Procyon lotor (Linnaeus). Raccoon.—An adult female raccoon was found dead along Indiana Highway 56, just west of Hanover, Jefferson County. Ten skulls were collected in Ripley and Jefferson Counties. This species is common in wooded areas and caves throughout the area investigated and is probably the most hunted nocturnal animal, although the pelts are of little monetary value.

Mustela vison mink Peale and Beauvois. Mink.—Five skulls were obtained from trappers, all of male specimens taken near Wirt, Jefferson County. Apparently minks are found in every county of the state since there are records from all except five counties in the work of Lyon (1936). Most of the records are from the sale of pelts to fur buyers.

Mephitis mephitis (Schreber). Striped skunk.—A female skunk was found dead along U. S. Highway 421 in Jefferson County. Measurements are: Total length, 630; tail, 225; hind foot, 65. In the area investigated this species was much less common the last few years than approximately 30 years ago, when the author frequently accompanied skunk hunters at night. At that time it was not unusual for six or eight skunks to be taken in a single evening with the aid of a good dog.

Odocoileus virginianus Zimmermann. White-tailed deer.—Apparently native deer disappeared from the Ripley and Jefferson County area about 1890, since Butler (Evermann and Butler, 1894), stated that they were still found in Ripley County "only a few years ago" (written in 1893). Deer were again noted in this region about 1941, at the time of the construction of the Jefferson Proving Ground. At that time the entire 55,000 acres were surrounded by a fence approximately 9 feet high, over which deer have rarely been seen to jump. Conceivably, deer were present within the proving ground when it was fenced in. Proving Ground officials estimate that there are from 1,000 to 2,000 deer within the reservation at present.

ACKNOWLEDGMENTS

This paper is a portion of a doctoral dissertation submitted to the Graduate School of the University of Cincinnati, Cincinnati, Ohio. The dissertation has been microfilmed and filed with University Microfilms, Ann Arbor, Michigan. The author is indebted to Roger W. Barbour of the University of Kentucky, who originally stimulated the writer's interest in this field, aided in some of the collecting and critically read this manuscript. He is also indebted to Jack Gottschang of the University of Cincinnati for advice and suggestions during the course of the study. Charles O. Handley, Jr., of the U. S. National Museum, gave valuable aid in subspecific identification of certain species.

SUMMARY

A study was made of the mammals of Ripley and Jefferson Counties, Indiana, an area largely composed of the unusual physiographic feature of low relief and poor drainage known as the "flats." Field studies included observations and collections over a period of six years. The mammals were trapped, shot, taken by hand, found dead or obtained from trappers and hunters. Museum skins and skulls were prepared from these specimens. Local residents were interviewed concerning their knowlegde of the past and present occurrence of easily recognized species. Museum specimens from this area were examined. Particular attention was given to the taxonomic status of critical subspecies. These results were correlated with the known distribution as given in the literature. Thiry-four species of native or naturalized mammals were found in the area. Gaps in known distributions were filled in some cases but unexplained anomalies remain in others.

LITERATURE CITED

Barnes, W. B. 1952. Zoogeographic regions of Indiana. Amer. Midl. Nat. 48: 694–699.

Bole, B. P., Jr. and P. N. Moulthrop. 1942. The Ohio Recent mammal collection in the Cleveland Museum of Natural History. Sci. Publ. Cleveland Mus. Nat. Hist., 5: 83–181.

Braun, E. Lucy. 1950. Deciduous Forests of Eastern North America. The Blakiston Co., Philadelphia. 596 pp.

Burt, William H. 1954. The Mammals of Michigan. Univ. of Michigan Press, Ann Arbor. 288 pp.

Cope, James B. and Russell E. Mumford. 1955. A preliminary report on bat banding in Indiana. Proc. Ind. Acad. Sci. for 1954, 64: 284–286.

Evermann, B. W. and A. W. Butler. 1894. Preliminary list of Indiana mammals. Proc. Ind. Acad. Sci. for 1893, 124–139.

HAHN, WALTER L. 1909. The mammals of Indiana. 33rd Ann. Rep., Dept. Geol. Nat. Res. Ind., 419–654.

HALL, E. RAYMOND AND E. LENDELL COCKRUM. 1953. A synopsis of the North American microtine rodents. Univ. Kansas Publ., Mus. Nat. Hist., 5: 373–498.

———., AND KEITH R. KELSON. 1959. The Mammals of North America. The Ronald Press, New York. 2 vols.

HAMILTON, WILLIAM J., JR. 1943. The Mammals of Eastern United States. Comstock Publishing Co., Ithaca, N. Y. 432 pp.

HANDLEY, CHARLES O., JR. 1952. A new pine mouse (*Pitymys pinetorum carbonarius*) from the southern Appalachian Mountains. Jour. Wash. Acad. Sci., 42: 152–153.

JACKSON, HARTLEY H. T. 1915. A review of the American moles. N. Amer. Fauna 38.

———. 1928. A taxonomic review of the American long-tailed Shrews (Genera *Sorex* and *Microsorex*). N. Amer. Fauna 51.

KIRKPATRICK, C. M. AND C. H. CONAWAY. 1948. Some notes on Indiana mammals. Amer. Midl. Nat., 39: 128–136.

LINDSAY, DWIGHT M. 1956*a*. Additional records of *Nycticeius* in Indiana. Jour. Mamm., 37: 282.

———. 1956*b*. Some bat records from southeastern Indiana. Jour. Mamm., 37: 543–545.

LYON, MARCUS WARD, JR. 1936. Mammals of Indiana. Amer. Midl. Nat., 17: 1–384.

———. 1942. Additions to the *Mammals of Indiana*. Amer. Midl. Nat., 27: 790–791.

MUMFORD, RUSSELL E. AND CHARLES O. HANDLEY, JR. 1956. Notes on the mammals of Jackson County, Indiana. Jour. Mamm., 37: 407–412.

OSGOOD, WILFRED H. 1909. Revision of the mice of the American genus *Peromyscus*. N. Amer. Fauna 28.

WETZEL, RALPH M. 1955. Speciation and dispersal of the southern bog lemming, *Synaptomys cooperi* (Baird). Jour. Mamm., 36: 1–20.

Dept. of Biology, Georgetown College, Georgetown, Kentucky. *Received 14 November 1958.*

40th ANNUAL MEETING

Arrangements are progressing for a gala meeting at Tacoma, Washington, 20–22 June. Include the 1960 Annual Meeting of the Society in your summer plans. Details appear in the February issue, page 157. Reservation blanks for dormitory accommodations will be mailed with the program to members on 1 June.

GENERAL NOTES

ARCTIC SHREW IN SOUTHERN WISCONSIN

The most southerly report of the arctic or saddle-backed shrew, *Sorex arcticus*, has been made by Nelson (Jour. Mamm., 15: 252–253, 1934) who found skeletal remains of one specimen in an owl pellet 20 miles southeast of Madison, Dane County, Wisconsin. This record may now be substantiated by the discovery of a population of these shrews 1 mile north of Madison. In 1958, arctic shrews were found living in a marsh of grass and sedge hummocks, mixed forbs and scattered clumps of cattail and willow and red-osier shrubs. This 2,000-acre tract had 6 inches of standing water in the spring of 1958. By fall the ground had become very dry.

One hundred snap traps were set in a square grid at 50-foot intervals for five days, 17–21 October. Bait was a mixture of rolled oats and peanut butter. The total catch was 20 *Sorex arcticus*, 5 *Sorex cinereus*, 46 *Microtus pennsylvanicus* and 6 *Blarina brevicauda*. Of the 19 arctic shrews which could be sexed, 8 were females and 11 were males. All were non-breeding adults. The density on the 5.7-acre grid was 3.5 arctic shrews per acre.

The arctic shrew has been regarded as an animal of coniferous swamps and bogs, although it has also been found in wet meadows, alder swamps, and a dry marsh area dominated by sedge and blue joint.—GARRETT C. CLOUGH, *Dept. of Zool., Univ. of Wisconsin, Madison.* *Received 13 July 1959.*

NOTES ON THE MARSUPIAL FEATHER-TAILED GLIDER OF AUSTRALIA

On the evening of 8 May 1948 I collected (with the aid of an unusual intermediary) a female *Acrobates pygmaeus frontalis* about 7 miles southeast of the tip of the Cape York Peninsula, Queensland. This specimen extended the known range of *Acrobates* approximately 200 miles to the northernmost point of the Australian mainland from near the upper Peach River, about 15 miles northeast of Coen. *Acrobates* is variously called pigmy or feather-tailed glider, "flying mouse," or simply "feather-tail." It should not be confused with the genus *Distoechurus*, the pen or feather-tailed possum (or phalanger) of New Guinea. *Distoechurus* lacks the gliding membranes that characterize *Acrobates*.

The circumstances surrounding the capture of this "feather-tail" were most unusual. I was hunting with a jack-light in open forest not more than ¼ mile west of Naru Point on Newcastle Bay. The forest trees were in bloom, and "flying foxes" (*Pteropus*), striped possums (*Dactylopsila trivirgata*), and sugar gliders (*Petaurus breviceps*) were feeding in the crowns of the bloodwood trees (*Eucalyptus polycarpa*). The light beam showed the white underparts of a tiny mammal moving rapidly about among the clusters of flowers, and my shot brought the unknown animal tumbling into the tangle of long grass under the tree. A prolonged search for the specimen was without success.

At daybreak I returned to the area, but again failed to find the animal. However, I did collect a carpet python (*Morelia argus*) near the base of the tree. Upon returning to camp I dissected the python and found the partially digested remains of an *Acrobates*. I was quite sure that the snake had eaten the dead or wounded animal of the previous night's hunt, now identified as a pigmy glider, but my field companion, the late Dr. G. H. H. Tate, expressed his doubts in print (Bull. Amer. Mus. Nat. Hist., 98:587–588, 1952), saying "it remains for X-rays to show whether or not the *Acrobates* contains lead pellets." I have now had the specimen (A.M.N.H. No. 155058), which was preserved in alcohol, X-rayed; the plate shows six shot, including one at the base of the skull. Tate also stated that the range of *Acrobates* is "from the extreme southern tip of Cape York Peninsula to Victoria;" this should be emended to read "from the extreme *northern* tip of Cape York Peninsula to *southeastern South Australia*." Only two other specimens are known from the upper

Peninsula: Philip J. Darlington, Jr., Museum of Comparative Zoölogy at Harvard College, shot an *Acrobates* out of a small gum tree at night near the upper Peach River in 1932; Donald Vernon, Queensland Museum, Brisbane, trapped a male (No. J 9452) in gallery forest near Bonanza Creek, upper Peach River, on 23 August 1948.

Tate (Novitates Zoologicae, 41:58–60, 1938) discussed the species of *Acrobates*, purportedly from "one of the small islands in Northern Dutch New Guinea," described by Lord Rothschild in 1892. The lack of recorded data on the collecting and acquisition of this unique specimen, the failure of collectors since A. Bruijn to find *Acrobates* again, and the extremely isolated geographic occurrence of this specimen are the factors which led Dr. Tate to the conclusion that the record is very probably in error. I concur in this opinion.

Tate (*loc. cit.*, 1952) remarked that he was reasonably sure that *Acrobates* did not occur in New Guinea. However, several mammals, once thought to be exclusively Australian, have now been recorded from central and western Papua. Such a list includes, among others: flat-skulled marsupial mouse (*Planigale novaeguineae*), 1 specimen, collected near Port Moresby; black-tailed rabbit-rat (*Conilurus penicillatus randi*), 1 specimen, Penzara; red-legged pademelon (*Thylogale stigmatica oriomo*), 10 specimens, two neighboring localities, Wuroi and Wassi Kussa River. We actually know very little concerning the distribution of mammals in the great south-central bulge of New Guinea across the Torres Strait from Cape York (a statement that still holds true for most parts of New Guinea). The collecting of *Acrobates* in the open forest of this area would occasion little surprise; this would be a much more logical extension of range than the appearance of this glider many hundreds of miles to the northwest on a small offshore island. *Acrobates* is easily overlooked, even in those parts of Australia where it is known to be common. The pigmy glider is rarely seen except when domestic cats bring it to the house. Occasionally it is discovered when trees are felled, or if hollow branches and knot holes of trees are carefully examined for its ball-like, dry-leaf nests. Fleay (GLIDERS OF THE GUM TREES, Melbourne, 1947) discussed at length the known details of the ecology and life history of *Acrobates*.

Laurie and Hill (LIST OF LAND MAMMALS OF NEW GUINEA, CELEBES AND ADJACENT ISLANDS, 1758–1952, Brit. Mus. [Nat. Hist.], 1954) include the genus *Acrobates* in their list, without comment, on the basis of the description by Rothschild (Proc. Zool. Soc. London, 546, 1892). For the present I suggest that *Acrobates* be relegated to the hypothetical list of New Guinea mammals.—HOBART M. VAN DEUSEN, *Archbold Expeditions, Dept. of Mammals, American Museum of Natural History, New York City. Received 27 February 1959.*

BEHAVIOR OF FLYING FOXES IN COASTAL NEW GUINEA

The following information was contributed to the writer by J. Victor de Bruijn, Advisor on Native Affairs, Netherlands New Guinea Government, and seemed so unusual that it is presented forthwith.

In February 1954, Dr. de Bruijn made a long walk along the north coast of Netherlands New Guinea from near Sarmi, which lies east of the mouth of the Mamberano River, close to Long. 139° E., to Hollandia. Most of his walking was done at or near dawn in order to benefit from low tides, and to walk on firm beach sand. One early morning he approached an area where fruits were floating on the surface of the sea offshore, apparently washed out from the mouth of a river. His attention was attracted by a concourse of flying fox bats dipping down to the water attempting to pick up the fruits. Presumably these bats belonged to the species *Pteropus neohibernicus papuanus* which is common throughout the Netherlands Territory.

Occasional bats dipped too far into the water, became caught and splashed in. The instant this happened, the flying foxes came to rest quietly on the surface with wings well spread. Thence they gradually rode in on the waves of the rising tide. The sea was not

too rough, and gradually they tumbled into the light surf and quickly proceeded to drag themselves out of the wave area. Without exception, the bats then crawled up the beaches, occasionally shaking themselves, and made for the low dunes above high water mark.

Beyond the dunes there was an area of saplings and stunted trees. One after another, the bats climbed up the trunks of these saplings and, once high enough—not more than 8 or 10 feet up, according to de Bruijn—launched themselves into the air, their trajectory just sufficient to clear the sand and get them successfully into flight.

In my own experience, I have never seen flying foxes in the water, nor am I aware of references in the literature to fruit bats performing in such a manner. Dr. de Bruijn has only seen this occurrence on the one occasion cited.—S. Dillon Ripley, *Peabody Museum of Natural History, Yale Univ., New Haven, Connecticut. Received 16 March 1959.*

THE LEAST TUBE-NOSED BAT IN KOREA

On 3 July 1954, Albert A. Barber, Warren D. Thomas and I captured an oriental racer, *Elaphe schrencki*, in the Central National Forest, 1½ mi. W Pup'yong-ni, 200 m. elevation, Korea. In the stomach of this snake I subsequently found three least tube-nosed bats, *Murina aurata ussuriensis* Ognev. In reverse order of ingestion by the snake the three bats were: an immature female, salvaged as a skin and skull (U.S. National Museum No. 299072); another immature female, preserved in alcohol (USNM 299962); and an adult, presumably a female, saved as a skull only (USNM 299963). These specimens provide the first record of occurrence of *Murina aurata* from the Korean Peninsula. The subspecies *M. a. ussuriensis* has been known previously from southeastern Siberia and from Japan.

The snake was taken along a small stream at the base of a wooded hill that supported numerous granite outcroppings. Either trees or outcroppings may have afforded a place of retreat for the bats.

The external measurements of USNM 299072 are as follows: total length, 65 mm.; length of tail-vertebrae, 25; length of hind foot, 10; length of ear from notch, 13; length of forearm (dry), 26.5. Cranial measurements of USNM 299072 and USNM 299963 are, respectively: greatest length of skull, 14.8, 15.7; condylobasal length, 13.2, 14.5; zygomatic breadth, 7.7, 8.1; breadth of braincase, 7.0, 7.5; depth of skull, 6.5, 6.7; interorbital breadth, 4.3, 4.5; length of upper tooth-row, 5.6, 5.8.—J. Knox Jones, Jr., *Museum of Natural History, Univ. of Kansas, Lawrence. Received 26 March 1959.*

RANGE EXTENSION OF *TADARIDA FEMOROSACCA* IN ARIZONA

The status of *Tadarida femorosacca*, the pocketed free-tailed bat, in Arizona has been reported recently by Cockrum (Jour. Mamm., 37:282–283). A specimen unknown to him at that time extends the range of the species approximately 135 miles northward from Tucson to 8 miles northwest of Roosevelt, Gila County. The specimen, a subadult male (?) bearing field number RWD 453, was taken 21 August 1952. It was found 1–2 hours after sunset crawling over a bedroll placed on the ground, apparently attracted by a gas lantern slung in a cottonwood tree overhead. The campsite was in Rock Creek Canyon, a shallow, open canyon, with a semipermanent stream. The vegetation of the canyon bottom was cottonwood, sycamore and desert hackberry. The vegetation of the south-facing slopes was typical Lower Sonoran with saguaro, prickly pear and paloverde dominant, while the opposing north-facing slopes were Upper Sonoran in aspect with scrub oak, mountain mahogany, buckbrush and manzanita the dominant woody forms.

The specimen measures: total length 105; tail 40; ear from notch 21; humerus 48.5. The characteristic skull measurements are: greatest length 17.6; zygomatic breadth 9.6; basal length 15.9; maxillary tooth row 7.3. In coloration it is darker and grayer, both dorsally and ventrally, than an adult male from Tucson. The ears of the Roosevelt specimen

are less massive, its hair is shorter, the lambdoidal crests are undeveloped, and its teeth are unworn compared to the adult.—Robert W. Dickerman, *Univ. of Minnesota, Museum of Natural History, Minneapolis, and* Bruce J. Hayward, *Zoology Dept., Univ. of Arizona, Tucson.* *Received 13 February 1959.*

NURSERY COLONIES IN THE PALLID BAT

Nursery colonies have been described for several species of North American bats, including *Tadarida cynocephala* (Sherman, Jour. Mamm., 18:176, 1937), *Myotis lucifugus* (Griffin, Jour. Mamm., 21:181, 1940), *Corynorhinus rafinesquei* (Pearson *et al.*, Jour. Mamm., 33:273, 1952), *Tadarida brasiliensis mexicana* (Krutzsch, Jour. Mamm., 36:236, 1955), and *Eptesicus fuscus* (Christian, Amer. Midl. Nat., 55:66, 1956). No such description exists for the pallid bat, *Antrozous pallidus*, although Orr (Proc. Calif. Acad. Sci., 4th Ser., 28:165, 1954) describes related processes. Most papers treat this subject only casually, emphasizing other phases of the reproductive cycle. This paper is concerned mainly with the behavior of the pallid bat in establishing nursery colonies and in the care and disposition of the young.

Sites of roosts.—Although observations were made in several locations, most of the data were collected at three localities. The most important of these is the Capay Schoolhouse, Capay, Yolo County, California. Capay is located on the western edge of the Sacramento Valley in the Inner Coast Range foothills. The schoolhouse is the most prominent building in the area. Cache Creek, a stream with water running during the entire year, is about 200 yards away. The attic houses at times a colony of *Antrozous pallidus* and of *Tadarida b. mexicana*. An occasional immature *Myotis yumanensis* has also been captured in this roost. The *Antrozous* use this schoolhouse for night and winter roosting also. During the day the bats roost in the enclosed eaves which open into the attic. They exit through a single opening near the peak at one end. Collections were made here by placing nets over this opening and trapping the bats as they flew out. A large deserted barn about 4 miles north of Capay housed a second colony. Only *Antrozous* were found here.

The third roost is a large barn, ½ mile south of Calistoga, in the Napa Valley. It is near an oak-covered hillside which gives way to vineyards on the valley floor. Colonies of *Antrozous pallidus*, *Eptesicus fuscus* and *Tadarida b. mexicana* may be found here from early spring to late fall. They roost in the box eaves.

Establishment of the nursery colony.—In early April male *Antrozous* leave the roost that the females will use as a nursery colony. An occasional male may remain; our banding studies indicate that these are late young of the preceding year. These males usually roost in an area of the building separate from the nursery colony. In late May and early June the *Tadarida* also leave. Because this departure coincided with the time of parturition in *Antrozous* in the first year of study, it was concluded that the *Tadarida* were driven out. Later observation has shown that they leave to form nursery colonies of their own. At the time of parturition, male *Antrozous* will have formed separate colonies. Inexplicably, an occasional lactating female will be found in these otherwise male colonies in June and July.

Parturition.—Birth has occurred in other areas as early as late April, but mid-May is the earliest time at which we have observed it. It may occur as late as mid-June. Timing varies with the year and importantly with individuals, for there will be young of various stages of maturity present in the same colony at any one time. The birth and growth of young has been fully described by Orr (*op. cit.*). However, the behavior of adults with young is less known.

Female *Antrozous* show an increased nervousness and irritability shortly before parturition. This heightened sensitivity continues until the young are weaned. Disturbances of any sort before parturition invariably cause the females to move to another roost. Disturbances

after parturition cause the females to move their young to a more secluded area of the roost.

The young cling tightly to the nipples of the mother for the first two or three days. Females with attached young have been captured in flight within the roost but we have no record of such a capture outside the nursery colony roost. This behavior agrees with Sherman's description (*op. cit.*) of *Tadarida cynocephala* but contrasts with recorded observations on two other species. *Myotis lucifugus* will carry young with them in flight for the first few days (Griffin, *op. cit.*). *Corynorhinus rafinesquei* normally leave their young at a roost while foraging but a female with young attached to a nipple has been observed (Pearson *et al., op. cit.*).

The nursery.—A concentration of young *Antrozous* was found at the Capay roost on 27 May 1956. Nine or ten young less than one week old (hairless; eyes closed) were clumped in a pocket formed by the overhang of the eaves beyond a wall. An adult female *Antrozous* was with the young. As the light struck her, she gave an intimidation buzz and bared her teeth. She did not attempt to leave until the light was brought very close to her, at which time she retreated into the eave away from the young. It appeared to us that her presence was not mere coincidence; she appeared to have been stationed as a guard near the young. At no time during the several minutes of observation did she attempt to single out a young animal presumably her own.

We were not able to locate a nursery of such young animals again. A second nursery colony was discovered on 18 June 1957 in a large deserted barn about 4 miles north of the Capay roost. It was composed of an estimated 30 adults with young. Bats were roosting in piles of burlap sacks. Young were still suckling and were estimated to be three to four weeks of age. In contrast to the much younger nursery at Capay, an individual adult seemed to handle her own young without much regard for other young. On 9 July the colony was still present in the barn but had moved behind a baseboard very near ground level. All young were able to fly by this date. This places the breakup of the nursery colony as such at about six weeks following parturition. Young begin to practice flight at this time and apparently master it in a few days' time. Until flight is mastered, the young continue nursing, of course.

A nursery colony was also present at the Capay Schoolhouse in 1958, but could not be located in May and early June. On 24 June, loud squeaking and the excitability of adult females led to the discovery of ten young bats estimated to be two weeks old. These bats were located in a crevice formed at the junction of the roof and chimney. Two adult females were with the young but did not remain with them. No other species of bats were present in the building.

The feeding behavior of adult females during the period of lactation differs from this behavior at other times of year. The Capay colony was followed for three years at all seasons. Normally, animals of both sexes would exit shortly after dark and forage for two or three hours before returning to the attic. A highway bridge about ½ mile away was a favored night-roosting site during the hours of foraging. Lactating adults, however, left for short periods only, perhaps 20–30 minutes, before returning to feed young. After feeding, this same pattern was repeated.

The sites near Calistoga differed from those near Capay in species composition. Nursery colonies of *Tadarida* and *Eptesicus* were close together but the *Antrozous* colony was well separated in the building. The colonies might well have been separated into different buildings. There seemed to be no interaction between them. In other respects, observations at the single Calistoga colony agree with those at and near Capay.

The adult females with young of both sexes remain together until well after young are able to live independently. In the latter part of August adult male *Antrozous* begin entering the colony and by fall it is difficult to distinguish the immature elements in the colony.—Albert J. Beck and Robert L. Rudd, *Dept. of Zoology, Univ. of California, Davis.* *Received 26 January 1959.*

FLIGHT BEHAVIOR IN LEAF-NOSED BATS

During the summer of 1954, I had the opportunity to photograph the flight of several species of tropical fruit-eating bats with the aid of equipment belonging to Donald R. Griffin, to whom I am indebted. Appreciation is also extended to Norman C. Negus for his help in preparing the manuscript. The work was supported financially by contracts between the Office of Naval Research and Harvard University.

When hanging up onto a ledge or other suitable roosting place, a bat executes a series of rapid movements. To the naked eye, it appears as though the bat were turning itself upside down by a forward motion of the body. The accompanying pictures (Plate I) indicate that in *Carollia perspicillata* the body motion is rather a lateral and upward sweep, over the head, of the posterior portion of the body. These and other pictures indicate that both wings beat with equal strength. Eisentraut (Die deutschen Fledermäuse, eine biologische Studie. Zentralblatt für Kleintierkunde und Pelztierkunde "Kleintier und Pelztier," 13 (4), 1937) suggests, without photographic evidence, that in *Myotis* hanging up may be accompanied by wing beats having greater strength on one side.

PLATE I

Sequence of body positions of *Carollia* in the act of hanging up.

Twelve fruit-eating bats, *Carollia perspicillata*, were released in a room where a generous slice of cantaloupe was hanging from the ceiling. Photographs were taken as a bat approached or hung up on the fruit. These black and white pictures were reproduced from 35 mm. Kodachrome slides.

Since none of the bats was marked, there was no way of knowing if the same bat was in more than one picture. However, the three pictures in Plate I seem to illustrate in chronological sequence the action which probably occurs in the process of hanging up. From a side view (Plate I, center) it is possible to see that, rather than turning upside down in a forward or backward motion, the flexible trunk region is thrown to the bat's flank and then up and over its head.

From other photographs not shown it is clear that some bats may begin to eat while going through the motions of hanging up. In pictures of *Glossophaga soricina* it is clear that some will feed while hovering before the fruit. Those which hovered before the fruit and ate in mid-air had their bodies arched considerably so that the hind feet were above the level of the head when viewed from the side.—Edwin Gould, *Dept. of Zoology, Tulane Univ., New Orleans, Louisiana.* *Received 6 February 1959.*

ABSENCE OF THIRD UPPER PREMOLAR IN *EUTAMIAS*

The occasional absence of the small upper premolar (P^3) in American chipmunks of the genus *Eutamias* (subgenus *Neotamias*) is established in the literature. I know, however, of no previous report of the absence of this tooth in the Asiatic subgenus *Eutamias*. Among 41

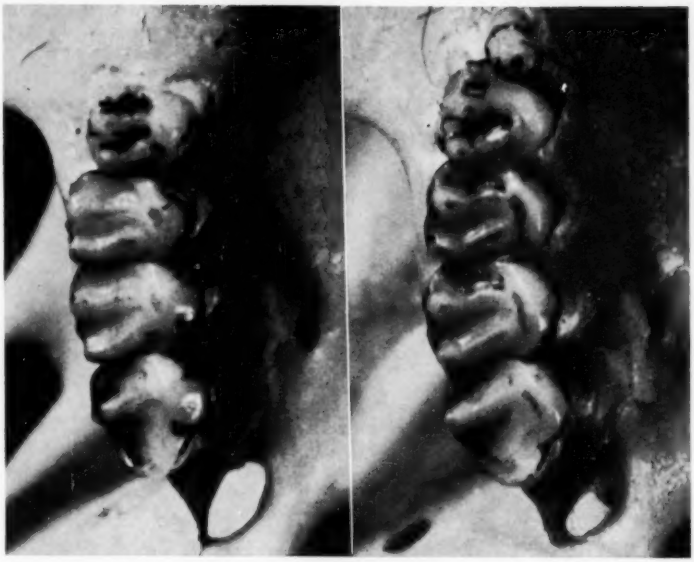


PLATE I

Right upper cheekteeth of *Eutamias sibiricus barberi*. LEFT: USNM 299582 from Central National Forest, 1½ mi. W Pup'yong-ni, Korea, which lacks the third premolar; RIGHT: USNM 298038 from Songu-ri, Korea, which has normal dentition. Approximately ×10.

skulls available to me of *Eutamias sibiricus barberi* Johnson and Jones from central Korea, I find two that lack P^3. One of these is an adult female (USNM 299582) from Central National Forest, 1½ mi. W Pup'yong-ni (Plate I). The other is an adult male (USNM 299583) from 3 mi. SSE Sumil-li. In each of these specimens the tooth is lacking on both sides and there are no traces of alveoli to suggest that the tooth was ever present. The P^3 is reduced in size in some other specimens.

Examination of 80 skulls in the U.S. National Museum of various subspecies of *Eutamias sibiricus* other than *E. s. barberi* failed to reveal any additional chipmunks lacking P^3, although it was reduced in size in several of these specimens.—J. KNOX JONES, JR., *Museum of Natural History, Univ. of Kansas, Lawrence. Received 26 March 1959.*

POSSIBLE EFFECT OF A COLD WINTER ON THE MARSH RABBIT

On three early morning trips in late June and July, 1953, I had counted marsh rabbits, *Sylvilagus p. palustris*, along the road berms on Cockspur Island, Chatham County, Georgia, at the rate of 27.6 per mile (Jour. Mamm., 36:144–145). During the spring and summer of 1958, on seven early morning trips over the same area, reasonably comparable to those of 1953, I found but 0.5 rabbits per mile, a reduction of 98.2 per cent. While there was no evidence that the application of Dieldrin to this area, by the U. S. Dept. of Agriculture in August 1957, caused the decline, I decided to check two other areas which were not poisoned and which were known to have good rabbit populations. One area was on Hutchinson Island, Georgia, and the other just across Back River in South Carolina, both adjacent to

U.S. Highway 17 Alt. The first area had been heavily hunted and trapped the previous winter, the other had not. One early morning was spent on these areas, at high tide. Some rabbits were seen, but not as many as expected. A little later I realized that most of them were full adult size, rather than half grown as expected. Of nine seen on this occasion, but one was subadult in size, and of the 14 seen on Cockspur but two were smaller than the full-grown ones. At this time of year I had expected at least half would be small.

The winter of 1957–58 was much colder than usual, consistently so from New Year's Day until 1 March. Normally we have many warm days and nights in January and February, and young rabbits have been found that were probably born about 1 February. It is offered as a theoretical consideration that the unusual weather may have inhibited breeding or may have actually killed young and/or adults.

Following the matter further, and to be sure that late summer breeding had not restored the usual numbers, careful examination of certain places in optimum habitat was made in November and December, 1958. By that time the pellets of the previous year were bleached, dissolved or hidden by vegetation. The result of these examinations showed that fresh pellets were present, though few; that rabbit cutting on rushes, etc., was scant; and that the usual heavily traveled rabbit paths were almost entirely lacking. On the poisoned area on Cockspur Island I did not find pellets or any other rabbit sign.

It seems plain that the marsh rabbit population was very low in numerous places where it has been adundant over many years. The cold winter may not be the reason, but it offers the most obvious explanation at the moment.—Ivan R. Tomkins, *1231 East 50th St., Savannah, Georgia.* *Received 23 January 1959.*

FOOD OF THE NORTHERN FLYING SQUIRREL IN NORTHEASTERN CALIFORNIA

Many small rodents are known to destroy large amounts of conifer seed in the Northwest and thus retard reforestation of logged areas. The northern flying squirrel, *Glaucomys sabrinus*, is a member of the coniferous forest fauna which, though less abundant than mice or chipmunks, could add to the total decimation of tree seed.

There are few reports of the food of the northern flying squirrel, probably because relatively few are caught. Seton (Life histories of northern animals, vol. 1, p. 444, 1910) thought that spruce seeds probably constituted its main food in northern Manitoba; but, from knowledge of the food habits of the southern flying squirrel, he believed that they would eat bark, buds, fruit, seeds, insects and birds. According to Cahalane (Mammals of North America, p. 420, 1947), the northern flying squirrel's staple food is nuts and seeds, especially of hickory, beech, white oak, pines and firs; but mushrooms and other vegetation, insects, birds and eggs are consumed. Sumner and Dixon (Birds and mammals of the Sierra Nevada, p. 397, 1953) reported the food of flying squirrels as principally seeds and nuts of pines, oaks and other trees and shrubs, but also insects, birds, eggs and meat whenever these items can be found.

This is a report of the food habits of the northern flying squirrel in forests of ponderosa pine (*Pinus ponderosa*) at Willard Creek and Black's Mountain, lodgepole pine (*P. contorta*) at Swain Mountain, and mixed red and white fir (*Abies concolor* and *A. magnifica*) at Swain Mountain; all localities are in Lassen County, California. The study was made in cooperation with the California Forest and Range Experiment Station, U.S. Forest Service, Berkeley.

Methods.—Animals were collected with snap traps set on the ground. Stomach contents were identified and the volume of each item estimated to the nearest 10 per cent; mean volumes were computed to the nearest per cent. Stomachs of 24 specimens, collected from January to December 1958, were analyzed.

TABLE 1.—*Foods of northern flying squirrels in Lassen County, California. Figures represent percentage volume (frequency of occurrence in parentheses)*

MONTH	No. examined	FOODS		
		Meat	Fungi	Lichens
Jan.	3	0	0	100 (100)
Feb.	2	5 (50)	0	95 (100)
March	2	0	10 (50)	90 (100)
April	1	0	10 (100)	90 (100)
May	1	0	10 (100)	90 (100)
June	0	–	— —	— —
July	1	0	100 (100)	0
Aug.	3	0	100 (100)	0
Sept.	2	0	100 (100)	0
Oct.	3	0	70 (100)	30 (67)
Nov.	3	0	67 (100)	33 (33)
Dec.	3	0	53 (67)	47 (100)
Mean	–	–	51	49

Results.—A summary of the findings is presented in Table 1. With one exception the lichen was hair moss (*Alectoria fremontii*); the stomach of an animal which was trapped in December, on an area where hair moss was not observed, was completely filled with staghorn lichen (*Usnea ceratina*). The fungi consisted of various hypogeous or epigeous forms; none was specifically identified.

During the winter months, when the snow cover was 2–5 feet deep, hair moss was the principal food of flying squirrels. With a decrease in snow cover in the spring, the squirrels consumed some fungi; in summer, their entire diet consisted of fungi. In the fall, the percentage of hair moss again increased, but fungi constituted over half the diet of the squirrels. Absence of snow cover during the fall, with the exception of a brief period in November, left fungi readily available.

Availability of different foods should be considered in a study of the diet of any animal. In this connection, it was noted that some tree seed was produced in each of the three forest types in 1957, and a good crop of seed was produced by both ponderosa and lodgepole pine in 1958. In addition, seeds of squaw mat (*Ceanothus prostratus*) became available in August in both pine types. Seeds of manzanita (*Arctostaphylos patula*) became available in the three forest types in September, but were scarce in the fir type. Despite the fact that seeds were readily available, none was present in the flying squirrels examined. Thus, the northern flying squirrel probably has little or no detrimental influence on forest regeneration in northeastern California. In contrast to the restricted diet of animals examined during the present study, investigators in other areas have found that flying squirrels consume a large variety of items, including tree seeds.

The flying squirrel's preference for fungi over lichens, when both were available, may be explained on the basis of food quality. Percentage total nitrogen content, as determined by the Kjeldahl method, has been used as an index of crude protein content, and therefore food quality, of plant material. On a dry-weight basis, the per cent total nitrogen of the main foods of the flying squirrel was as follows: staghorn lichen, 0.44; hair moss, 0.69; and fungi (average of three species), 3.79. Thus, high quality food (fungi) was eaten in preference to low quality food (lichens) whenever the former was available. However, this does not explain why hair moss was eaten in preference to pine seed, which has a nitrogen content of 3.32 per cent, when both were available.—STURGIS MCKEEVER, *Dept. of Zoology, Univ. of California, Davis.* *Received 9 March 1959.*

SQUIRREL WEIGHTS AND POPULATIONS IN A MINNESOTA WOODLOT

A study of the squirrel population in a 25-acre grazed woodlot in southeastern Minnesota was conducted from 13 September 1957 to 15 May 1958. This study area was located on the Gerhard Kason farm 1.5 miles east of Harmony, Fillmore County, Minnesota. The woodlot, composed primarily of white oak (*Quercus alba*) and hickory (*Carya cordiformis*) was surrounded by agricultural land, utilized for pasture and corn production.

A total of 2,300 trap days in 44 trapping locations within the woodlot were carried out during the eight months. Twenty National live-traps, 9.5 X 9.5 X 28 in., with hickory nuts and shelled corn as bait, were used during the study. Each animal was tagged, weighed, and its age determined at first capture, with the last two steps being carried out at all successive captures. A metal tag, size B style 10005 National Band and Tag Company, was secured in each ear, and although 11 animals lost one ear tag over the winter months (these were replaced in the spring) no animals were taken which had both ears torn, indicating the loss of tags. Weights were recorded by means of a spring scale which was checked weekly against a standard weight. Aging characteristics as described by Allen (Michigan fox squirrel management, Game Div. Publ. 100, Mich. Cons. Dept., 1943) were used in determining the age of each animal.

Of the 86 squirrels tagged, 67 were fox squirrels (*Sciurus niger*) and 19 were gray squirrels (*S. carolinensis*). The sex ratio was approximately 1:1, with 35 male fox squirrels to 32 females and 11 male gray squirrels to 8 females. Of the 86 animals handled, 38 were captured only once, 17 were handled twice, 8 were taken three times, 13 were captured four times, 4 animals were taken five times, 4 were captured seven times, 1 taken eight times, and 1 male fox squirrel was handled ten times. Fifty-eight per cent of the animals captured in the fall were mature, whereas 87 per cent of the spring catch were classified as adults.

The weights of the mature fox squirrels ranged from 507 gm. to 1000 gm., the heaviest being a female captured in February (Table 1). The average weights of the male fox squirrel varied little with the season, ranging from a low of 722 gm. to a high of 765 gm. The average weights of the females, however, ranged from 717 to 850 gm.

The weights of the mature gray squirrels ranged from 383 gm. to 713 gm., the heaviest being a male captured in November. During January, 7 mature gray squirrels were trapped in the town of Harmony, Minnesota, and a comparison of their weights to the animals of the woodlot was made. The squirrels trapped in town were considerably heavier than those of the woodlot (Table 2).

The trapping results indicate that the fox squirrels had two litters per year as reported by Allen (*op. cit.*). Three immature fox squirrels were taken from 8–11 May, indicating the presence of spring litters. During October the weights of six animals indicated the presence of a summer litter. The owner of the woodlot, who has lived on the farm for some 62 years, had informed me that I would find two litters per year.

Population estimates, based on the Schnabel modification of the recapture method

TABLE 1.—*Mature fox squirrel weights in grams*

MONTH	MALE			FEMALE		
	Avg.	Range	N	Avg.	Range	N
Sept.	722	653–793	5	717	668–763	4
Oct.	728	507–853	13	724	703–793	14
Nov.	765	663–930	15	726	633–863	5
Feb.	745	670–830	4	850	750–1000	4
April	747	620–880	18	786	700–850	16
May	749	640–890	14	717	620–780	9

TABLE 2.—*Mature gray squirrel weights in grams*

MONTH	MALE			FEMALE		
	Avg.	Range	N	Avg.	Range	N
Sept.	560	383–643	5	602	573–630	2
Oct.	593	— —	1	583	573–593	2
Nov.	614	540–713	7	no captures — —		-
Jan. (town)	684	590–770	5	645	550–740	2
Feb.	510	500–520	2	—	— —	-
April	—	— —	-	500	— —	1
May	—	— —	-	520	— —	1

(Ricker, Indiana Univ. Publ., Sci. Ser., 15:1–101, 1948) gave an average fall population of 42.2 squirrels for the 25-acre woodlot and a spring population of 35.6 animals. A check of the two woodlots (19–28 May) within a half-mile radius produced six captures in a total of 160 trap days. Of these six, two had been previously captured in the intensively trapped woodlot.

The high population in the 25-acre woodlot under study is undoubtedly the result of a number of factors. Probably the most important are: (1) natural and cultivated foods supplied by the oaks and hickories, along with corn on the surrounding agricultural land, are abundant; (2) many mature oaks supply the animals with an abundance of natural dens; (3) an open corn-storage shed on one edge of the woods supplies food throughout the year and is used extensively during the winter months by the squirrels; and (4) only four gun hours were spent in the woodlot in 1958, with negative results.—BEN L. THOMA, *1121 Argyle,* AND WILLIAM H. MARSHALL, *Univ. of Minnesota, St. Paul.* *Received 27 January 1959.*

[Paper No. 4064, Scientific Journal Series, Minnesota Agricultural Experiment Station, St. Paul 1, Minnesota.]

AQUATIC VOLES

In the summer of 1933, beginning 15 June, about a week was spent trapping *Microtus* and making observations at a marsh in Jackson Hole, Wyoming. The marsh was about 1 mile long and about 300–400 yards wide. It had been dry through the winter but had filled during the spring run-off to a depth ranging up to 3 feet in the part I investigated. The chief vegetation in the water consisted of reeds (*Scirpus*), distributed in large and small patches. The old growth of reeds of the previous year formed a dense tangled brown mass, through which grew the new green reeds. There were a few small patches of cattail and some submerged vegetation, including *Ranunculus*. Pasture lands surrounded the marsh, and these were too closely grazed to offer cover for voles except in a few small spots.

In wading among the reeds it was noted that the tangles of old reeds were occupied by a considerable vole population. The voles were living beyond the land, just over the water. Many runways had been cleared through the masses of dry reeds and here and there were feeding platforms and dropping stations, and tucked away in the dense tangles were many nests.

To determine what species were inhabiting the reeds, a rather extensive trapping operation was begun. Thirty-one voles were captured, all of them *Microtus pennsylvanicus pullatus*.

About 50 nests were found in the reeds, and six of these contained young. Usually the nests were placed in the denser tangles of dry reeds, the voles seeming to judge nicely between dense and denser tangles. Usually the well-concealed nests rested 3 or 4 inches above the water, but a few actually touched the water, which may have risen after the

nest had been built. The nest material consisted of shredded reeds, shredded more finely for the lining. Occasionally a little cattail was used for the outer structure and one nest was lined with cattail "down." The average domed nest was 5 or 6 inches in diameter; the doorway was on one side and led into a chamber 2 or 3 inches across.

The aquatic life of the voles was based chiefly on a reed economy throughout. The principal food for most of the population was the bark of the new growth of reeds. Sometimes, on hearing a vole chewing, I would look toward the sound and see a tall reed getting an inch or two shorter at regular intervals. A Vole was busy cutting sections off the base of the shortening reed. With each cut, the reed, held erect by its neighbors, slid down a distance equal to the length of the cut section. It did not take the vole long to have the reed at its feet in neat little pieces that it could easily handle, available for feeding. There were many feeding platforms consisting of an accumulation of these short sections from which the green bark had been eaten.

As one would expect, the reeds surrounding occupied nests showed the heaviest use. At a few nests, practically all reeds within a 10-yard radius had been cut over a period of time. After being cut, the remaining part of the stem continued to grow, so that cut reeds of varying heights, as much as 4 feet, were present. The older the cut the taller the reed. Only the green bark of the stem was eaten, but a vole in captivity also ate the submerged tender white basal part.

Voles were not living in the closly grazed pasture bordering the marsh, but were present in a patch of plowed sod 20 yards from the water. Eighteen voles were taken in the plowed area, all of the dry-land species, *Microtus montanus caryi*. Three nests were found containing young. Here, where two extreme types of habitat were available, the two species had segregated completely so far as their home sites were concerned, choosing the habitat most nearly characteristic for their species.

On the shore of the marsh opposite the plowed sod was a fringe of sedge and rush, only a few feet wide, growing in water an inch or two deep or in wet mud. Here there were no nests, nor cover for nests. But there were many cuttings, showing that voles were coming here to feed extensively on the sedge and rush. Trapping in this fringe showed that both species were attracted by this choice food. Trapping in the fringe yielded 11 *Microtus montanus* and 19 *Microtus pennsylvanicus*. The dry-land voles crossed 20 yards of closely grazed pasture to feed along the marsh, and those from the reeds swam across at least 10 yards of open water to reach the shore vegetation. On one occasion I observed an undisturbed vole leave the shore and swim the 10 yards to the reeds.

Although part of the population in the reeds visited the shore to feed, many others, living opposite a part of the shore with no special food attraction, probably seldom went ashore. One group of voles occupying a patch of reeds surrounded on all sides by at least 30 yards of open water probably did not venture beyond their reed island.

About 125 yards from the shore of the marsh was a small area in a depression containing matted grass and a little patch of rush. There were many runways and burrows that had been dug in the soil. Trapping yielded 14 *M. pennsylvanicus* and 7 *M. montanus*. Here was a habitat of an intermediate type often used by both species, so it was not surprising to find both species present. In many intermediate habitats I have found both species present. But *M. pennsylvanicus* will use much wetter areas, and *M. montanus* even flourishes on the very dry mesas high in the mountains. Here vegetation is so short and sparse that cover consists chiefly of pocket gopher tunnels out of which the voles make brief appearances to feed.

By September the marsh was almost dry and I saw no recent signs in the reeds where voles had been abundant in June. There was some sign in the surrounding pasture but not a great deal.

Another species of meadow vole, the large *Microtus richardsoni macropus*, is perhaps more aquatic than *M. pennsylvanicus*. In Jackson Hole it is found along mountain creeks and ponds from the valley floor to about 10,000 feet. The best opportunity for watching

these voles is along a miniature brook, a foot or two wide, flowing through a high mountain meadow. There are many little landing platforms along these tiny creeks, and burrows leading into the banks from the water's edge. Sometimes there is an entrance under the water. Swimming and diving are routine for voles in such locations.—ADOLPH MURIE, *Crater Lake National Park, Medford, Oregon. Received 17 February 1959.*

THREE LITTERS IN A PINE MOUSE NEST

Although the northern pine mouse, *Pitymys pinetorum scalopsoides,* is a common mammal throughout much of the Northeast, its fossorial habits render difficult any but infrequent and fortuitous observations of its breeding behavior. Since no report of communal nests nor of multiple litters in a single nest has been seen in the literature, the following account is presented.

On 22 April 1953, while plowing a garden at Manorville, Long Island, New York, a nest of the pine mouse was unearthed. Eleven mice were taken from the nest, four killed by the plow and seven alive. It is believed that none escaped after the nest was exposed. The specimens included an adult female and three litters of young. The female, No. 85 in my collection, was lactating and contained two embryos 6 mm. long. She measured 134, 27, 19 and weighed 33.7 grams. The oldest litter was composed of three subadult males and one female weighing 19.0, 20.5, 21.1 and 19.6 grams. One male, No. 86, was preserved and measured 115, 20, 16. The testes measured 4X3 mm., not yet of breeding size. The second litter was composed of three young with eyes fully open weighing 8.1, 8.3 and 8.5 grams. A female, No. 87, was preserved and measured 74, 13, 14. The third litter also contained three young with eyes closed or slightly open weighing 6.4, 6.5 and 6.9 grams. None was preserved but they were distinctly smaller as well as lighter than the others.

On the basis of the known rate of development, it is estimated that the three litters were from 18 to 20 days, from 10 to 12 days, and 8 or 9 days old. Since four is suggested as the maximum number per litter in this species, and the two smaller litters are obviously only a few days apart in age, it is evident that they were born to different females. A similar incident wes reported by Hansen (Jour. Mamm., 38: 523, 1957) who found two female *Peromyscus maniculatus* and their litters in a single nest. If we assume that the oldest litter and one of the other two belonged to the captured female and include her unborn young, a progressive decrease in litter size from four to three to two is indicated during the first four to six weeks of the breeding season.

The nest itself was globular in shape, from 6 to 7 inches in diameter and 22.6 grams in weight; it was heavily infested with parasites. It was composed largely of dried grasses with a few leaf fragments and several entire privet leaves. It had been located between 4 and 6 inches below the surface and only one burrow was found leading from it.—GILBERT S. RAYNOR, *Manorville, Long Island, New York. Received 11 March 1959.*

UNUSUAL HABITATS OF GRASSHOPPER MICE IN NEW MEXICO

On 29 July 1958, two specimens of the northern grasshopper mouse, *Onychomys leucogaster ruidosae* Rehn, were obtained by us at an elevation of approximately 8,800 feet in Bear Trap Canyon, San Mateo Mountains, 19 miles west and 20 miles south of Magdalena, Socorro Co., New Mexico. One specimen was taken from a burrow entrance under a log, the other from a *Microtus mexicanus* runway in grass. Other animals taken in the same general area were: *Microtus mexicanus, Reithrodontomys megalotis, Sylvilagus floridanus, Tamiasciurus hudsonicus, Sciurus aberti, Eutamias cinereicollis* and *Thomomys bottae.* Vegetation in the immediate area consists of yellow pine (*Pinus ponderosa*), Douglas fir (*Pseudotsuga taxifolia*), quaking aspen (*Populus tremuloides*), Gambel oak (*Quercus gambelii*) and Englemann spruce (*Picea engelmanni*).

On 25 October 1958, another specimen was collected in grass at an elevation of approximately 8,000 feet in the Animas Mountains, 26¾ miles south and ¾ mile east of Animas, Hidalgo Co., New Mexico. Other animals taken in this same general area were: *Reithrodontomys megalotis, Peromyscus boylei, Eutamias dorsalis, Neotoma mexicana* and *Thomomys umbrinus.* The prominant vegetation in this area includes Mexican white pine (*Pinus ayacahuite*), alligator juniper (*Juniperus deppeana*), silverleaf oak (*Quercus hypoleucoides*), netleaf oak (*Quercus reticulata*), gray oak (*Quercus grisea*) and Douglas fir.

The specimens from the San Mateo Mountains, subadult female and male, catalog Nos. 5007 and 5008 UNMCV, are preserved in the University of New Mexico Collection of Vertebrates, as is the specimen from the Animas Mountains, subadult female, catalog No. 5558 UNMCV.

According to Bailey (N. Amer. Fauna, 53: 140, 1931), "The animals are generally found among the desert shrubs collectively called sagebrush, greasebush and rabbit brush, but also out on the sandy flats and even among the scattered nut pines and junipers. . . . The mice were common in the foothill region of the White, Capitan, Jicarilla, Manzano, and Sandia Mountains, and west of the Rio Grande Hollister found them abundant near Burleigh, in the grassy parks of the Bear Spring Mountains up to nearly 8,000 feet, and also in the grassy parks and openings and sandy sections in the Gallina and Datil Ranges." Bailey (N. Amer. Fauna, 35, 1913) includes the Bear Spring Mountains in the Transition Zone. In contrast to the above, the localities in the San Mateo and Animas Mountains are referred by Bailey to the Canadian Zone.

Investigators usually have considered *Onychomys* to be an animal associated with Lower or Upper Sonoran Zones. If this is the case, one might expect mountain ranges which exceed these zones to be partial barriers to *Onychomys* distribution. Our findings suggest that mountain ranges, at least in the Southwest, prove ineffective barriers to northern grasshopper mice.—CLYDE J. JONES, EUGENE D. FLEHARTY AND ARTHUR H. HARRIS, *Dept. of Biology, Univ. of New Mexico, Albuquerque.* *Received 19 January 1959.*

THE ENTEPICONDYLAR FORAMEN IN *PEROMYSCUS*

In a recent paper, Hooper (Misc. Publ. Mus. Zool., Univ. Mich., No. 105, 1958) presented evidence bearing on the status of the subgenus *Ochrotomys* of the genus *Peromyscus*, and suggested that this subgenus should be elevated to generic rank. As is well known among taxonomists, several workers in this area have believed, or currently believe, that this arrangement would be better than the presently accepted classification. It is pertinent, then, that the following information be made a matter of record.

While dissecting specimens of *Peromyscus leucopus* and *P. nuttalli*, for the purpose of general myological comparison, I noticed that an entepicondylar foramen was present in *P. leucopus*, but was absent in *P. nuttalli*. Examination of additional skeletal material revealed that *P. nuttalli* is unique in this respect among the species of the genus available to me. Representatives of all species of *Peromyscus* in the skeletal collection of the University of Michigan Museum of Zoology have been examined, with no exceptions to this apparent rule coming to light. The species examined, with the numbers of each are: *P. banderanus*, 3; *P. boylei*, 25; *P. californicus*, 7; *P. crinitus*, 2; *P. difficilis*, 9; *P. eremicus*, 25; *P. floridanus*, 6; *P. furvus*, 5; *P. gossypinus*, 3; *P. guatamalensis*, 1; *P. hylocetes*, 1; *P. leucopus*, 25; *P. maniculatus*, 25; *P. melanophrys*, 9; *P. mexicanus*, 6; *P. nasutus*, 1; *P. nuttalli*, 4; *P. perfulvus*, 2; *P. polionotus*, 1; *P. truei*, 19; *P. yucatanicus*, 3. In those species represented by longer series, 25 was considered a sufficient sample.

It is to be hoped that those having access to skeletal material of other species, as well as additional specimens of those species listed above, will examine them for this character. If *P. nuttalli* actually is unique in lacking the entepicondylar foramen, this fact would add weight to the argument that *Ochrotomys* should be considered a distinct genus.—GEORGE C. RINKER, *Dept. of Anatomy, Univ. of Michigan, Ann Arbor.* *Received 13 April 1959.*

RENAMING OF *RATTUS RUBER MELANURUS* LAURIE AND HILL, 1954

Rattus ruber melanurus Laurie and Hill, 1954 (List of land mammals of New Guinea, Celebes and adjacent islands, 1758–1952, p. 112) from northeastern New Guinea is preoccupied by *Rattus melanurus* Shamel, 1940 (Jour. Mamm., 21: 76) from Pulo Miang Besar, off southeastern Borneo. I therefore propose for it the name *Rattus ruber giluwensis*, derived from the locality of the type specimen.—J. E. Hill, *Dept. of Zoology, British Museum (Natural History), Cromwell Road, London, S. W. 7. Received 13 July 1959.*

ELEPHANT SEALS IN ANTARCTICA

Southern elephant seals, *Mirounga leonina* (Linnaeus), were first reported in large groups on the Antarctic continent by the Australians. In February 1957, over 70 were counted near their Davis Station in Vestfold Hills (Lat. 68° 35′ S, Long. 77° 58′ E), and over 400 were seen in March. In March 1958, 676 were counted in this area ("Antarctic," N. Z. Ant. Soc., 1 (7): 169, Sept. 1957, and 1 (10): 263, June 1958). Most of these were molting bulls.

While at the Wilkes Station (Lat. 66° 15′ S, Long. 110° 31′ E) during the IGY, Richard Cameron, Frederick Charlton and I discovered a group of 19 elephant seals on 12 January 1958. These were located on the western side of Peterson Island, in a bay slightly north of the mid-point. Peterson and Browning Islands are the two most southerly of the Windmill Islands group. This was the only area within the Windmills where this species was seen. Most of these seals appeared to be immature.—Carl R. Eklund, *Polar Branch, Army Office of Research and Development, Washington, D. C. Received 22 June 1959.*

OFF-COURSE MIGRATION OF A NORTHERN FUR SEAL

On 16 October 1958 an Eskimo, Fred Thrasher, shot what appeared to him an unusual animal as it swam in sea water near the settlement of Letty Harbour, Northwest Territories (69° 50′ N, 124° 24′ W). Neither Thrasher nor any other person—Eskimo or white—at Cape Parry, N.W.T., had seen such an animal before. The skin was turned over first to the Royal Canadian Mounted Police and later to the author for identification. Identification of the specimen was confirmed by Dr. H. D. Fisher of the Fisheries Research Board of Canada, Montreal, from a photograph supplied by Sgt. W. L. Carey of the Aklavik detachment, R.C.M.P. An effort was made to obtain the skull of the animal as well, but the native had disposed of the carcass in the meantime.

The pelt was that of a northern fur seal, *Callorhinus ursinus*. The underfur was very fine and dense, the color dark brown on the back, silvery brown on the sides and belly. The flat skin measured 39 in. from the tip of the nostril to the tip of the tail and 52 in. from the tip of the nostril to the distal end of the backward-directed flippers. Judging by these measurements alone, it was presumed that the animal was a young of the year.

The taking of this specimen at the Letty Harbour location represents a remarkable example of sporadic wandering from the normal species migration route along the Pacific coast. Northern fur seals breed on the Pribilof Islands in the Bering Sea. The females migrate as much as 3,000 miles along the west coast to California waters. As far as can be determined, there are only three previous records of this species having been taken along the Arctic coast (McEwen, Jour. Mamm., 35:444, 1954): one at Point Barrow in 1925 or 1926, another at Barter Island in 1942, and the third in the extreme northeastern part of Yukon Territory (68° 48′ N, 136° 42′ W) in 1951. Miller and Kellogg (U.S. Nat. Mus., Bull. 205:783, 1955) state that the species is found casually as far as Point Barrow, Alaska. To reach the Letty Harbour region, the animal in question must have traveled well over 2,000 miles by sea off the normal course of the species. The site at which it was taken is approximately 350 miles farther east than McEwen's 1951 record.—A. Radvanyi, *Canadian Wildlife Service, Aklavik, N.W.T. Received 15 April 1959.*

NOTES ON COYOTES IN SOUTHERN NEW ENGLAND

Five recent records of the occurrence of coyotes, *Canis latrans*, in southern New England suggest that this predator is spreading from New York and Vermont. The origin of four specimens killed in Massachusetts and one killed in Connecticut is problematical, but may well have been Vermont. Coyotes have been taken in nearly all 14 Vermont counties, with the first record in 1942. Four of the five specimens from Massachusetts and Connecticut were identified by W. J. Hamilton, Jr. There appeared the possibility that one Massachusetts animal examined had some dog blood.

The first record of the coyote in Massachusetts was in December 1957. The animal was shot near Otis, in the southwestern portion of the state, by Harry Soules, Jr., of Waynesboro, and was identified by Barbara Lawrence. The other three Massachusetts specimens were trapped by the author in mid-November 1958, on Prescott Peninsula of Quabbin Reservation, in the central part of the state. Their size and small amount of tooth wear suggested that all were young of the year.

No measurements were taken of the mature male Connecticut coyote, which weighed 35 lb. It was badly afflicted with mange. Measurements (in mm.) of the Massachusetts coyotes (25.8-lb. male, 24.7-lb. female, and 27-lb. female) were, respectively: total length, 1070, 1170, 1160; length of tail, 320, 310, 320; hind foot, 190, 175, 180.

The Prescott Peninsula coyotes were taken in fox sets. The male and first female captured were drugged with paraldehyde and kept in captivity for 14 and 3 days, respectively. About 12 cc. of paraldehyde, injected intramuscularly, proved an effective anesthetic for 4–5 hours.

All three coyotes barked when approached in the trap, the bark resembling that of a collie. Both females showed great aggressiveness, not hesitating to snarl, charge, and attempt to bite the trapper. The male was less aggressive, but this may have been due to his more vulnerable position. He was tangled under a small brush pile, in the open. The females were entwined in young birch trees and still could maneuver considerably. All three were primarily interested in escape and became aggressive only when provoked. Once caged, the coyotes showed the same mixture of fear and bravado. They growled at visitors, but slunk into a corner when approached. Both chewed on wooden portions of their cages in efforts to escape. They were most active at night. At no time was either caged animal heard to utter a sound above a growl.

Examination of initial droppings and stomach contents of both captives revealed only trap site debris. The small female, shot while in the trap, had a stomach full of deer hair, bone and hooves. The stomach of the Connecticut coyote contained 90 per cent deer remains and 10 per cent apple. In this case, the food might easily be carrion, as Connecticut has a legal year-round deer season. In the former case, it is more likely that the coyote killed the deer, as no hunting is allowed on the Quabbin Reservation.

Sightings in November and tracks in December 1958 indicate that there were at least two more coyotes on Prescott Peninsula at that time. Based on the coyote's success in the Adirondack Mountains of New York, and in parts of Vermont, it seems to be only a matter of time before the creature becomes established in the wilder portions of New England.—LAURENCE P. PRINGLE, *Massachusetts Coop. Wildl. Res. Unit, Amherst.* *Received 25 February 1959.*

IT IS POSSIBLE: A CORRECTION

While searching literature for possible records of Mustelidae from Baja California, Mexico, I came upon a record by Hall in his most thoroughly documented work "American Weasels" (Univ. Kans. Publ., Mus. Nat. Hist., 4:1–466, 1951), the locality of which had given the author some concern. The finding of this dried specimen in a place so remote from any known points of capture of the species, and its subsequent placement in an accessible collection, make this correction in detail necessary.

On page 326 Hall states, "A skull of a young animal, not here identified to subspecies, from Potholes, in the Colorado River Valley, 10 miles northeast of Bard, Imperial County, California, may have closest relationship to *M. f. latirostra*. Additional comment on this specimen is offered in the account of *M. f. neomexicana*."

On page 337 Hall further states, regarding this specimen, "Probably the geographic ranges of *M. f. neomexicana* and *M. f. latirostra* do not meet; the only evidence of the existence of weasels in all of the large area, comprising western Arizona and the deserts of eastern California, which intervenes between the ranges of the two subspecies is the skull of a young individual, no. 68842, Mus. Vert. Zoöl., from 10 miles northeast of Bard, Imperial County, California. There, on December 29, 1932, Jack von Bloeker, Jr., retrieved the weathered skull with some of the vertebrae attached, from the top of a woodrat's nest beneath a mesquite tree near the west bank of the Colorado River."

Since 1923 I have owned a ranch at the locality where the dried skull was picked up and during the operations of the property many trips were necessary to maintain it. It so happened that in the spring of 1930, when bound for the ranch, I picked up an immature road-killed weasel between San Diego and Lemon Grove, almost a topotype of the race now known as *Mustela frenata latirostra*. The day was warm and part of the 185-mile journey was across the desert.

Not having the necessary tools to eviscerate the specimen on the spot, but having such equipment at the ranch, I decided to carry the animal through in hopes of preserving it upon arrival. However, the desert ride on the warm day was too much for the specimen and upon arrival it was in a high state of putrefaction and was not savable. The dead weasel was thrown out into the mesquite thicket before turning into the ranch. Without question this is the "skull with . . . vertebrae attached" found on the wood rat's nest later by Mr. von Bloeker, and is an example of how, through some inadvertent act, complications can arise, even in natural science!

While precise identity was not made by Dr. Hall, the astuteness shown in his diagnosis of this weirdly taken immature specimen casts a most complimentary view on the infinite care he had taken in building this monumental work.—LAURENCE M. HUEY, *San Diego Society of Natural History, Balboa Park, San Diego, California.* *Received 24 March 1959.*

DAILY PATROL OF A *MEGAPTERA*

The long-distance migrations of whales have commanded some attention, though by no means enough. One hears less, however, of the smaller-scale circulations of cetaceans. A paper by Caldwell (Jour. Mamm., 36: 304–305, 1955) reports sighting the same *Tursiops truncatus* three times at intervals of 84 and 55 days in an area of about 0.12 square sea mile.

We have to report the daily patrolling of a somewhat larger beat by a single humpback whale, *Megaptera novaeangliae*, which repeatedly traversed an area of about 20 square sea miles (4x5).

Over ten days (29 October through 7 November 1958) we observed a large *Megaptera*, recognized as the same one, in about the same near-shore area, and on six of these days at about the same time of day. This was near Fletchers Neck, which is about 10 sea miles southwest of Cape Elizabeth, near Portland, Maine.

Megaptera novaeangliae is a species in which minor individual variations are often sufficiently conspicuous and distinctive to enable even a shipboard observer to recognize individual whales out of small groups. Of the four *Megaptera* that we saw during these days, our subject was readily distinguishable by its larger size, by the shape of the dorsal fin or hump (especially variable in this species), and by the distinctive color pattern of the underside of the flukes (markedly unlike any of the others with it). The characteristic serrated trailing edge of the flukes was conspicuous; the dorsal fin was often seen to wobble

in the wind, or as waves slapped it. Both sides of the flippers were white, as usual in the western North Atlantic. The rest of the whale's upper surface was a very dark gray, nearly black, with lighter scratches and grayer patches. This animal was about 14 m. long with 4.5-m. fluke span (estimated by comparison with our 12-m. boat). We observed and photographed it from the boat and from the air; it was not at all shy and often came near the boat, frequently surfacing within 5 m. It breached occasionally, but luckily at some-

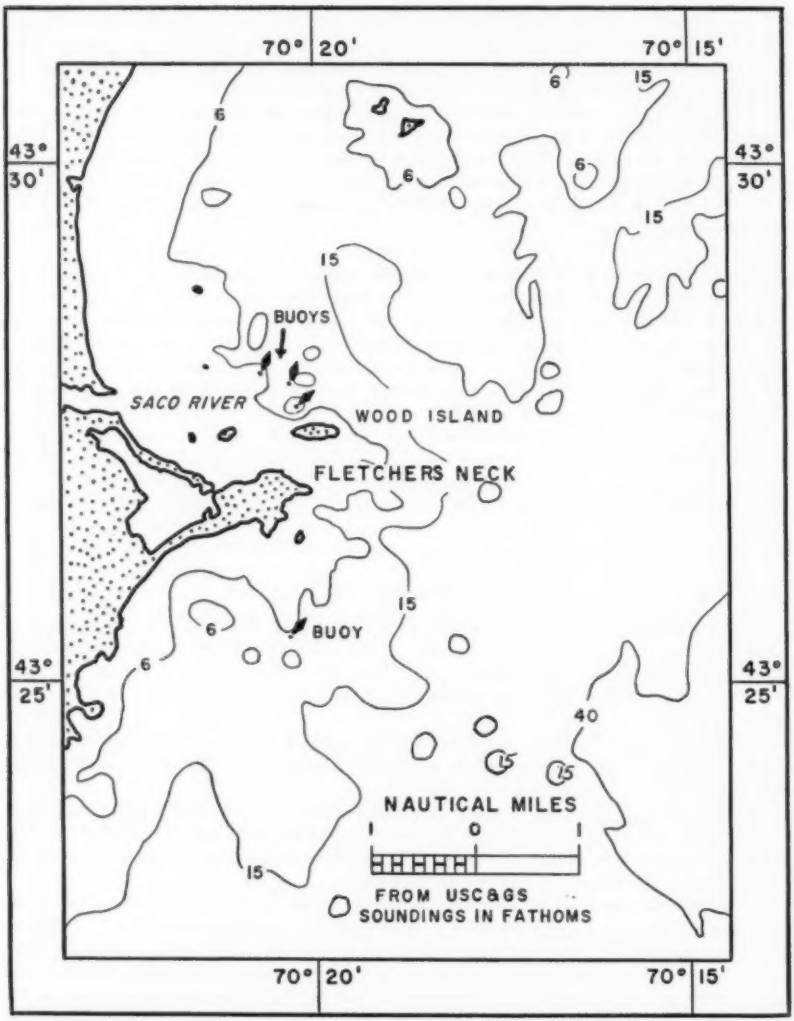


FIG. 1.—Chart of the area frequented by a humpback whale.

what greater distances. It also lobtailed briefly and spectacularly three times, and sometimes raised its head well out of water. It was by itself almost all the time we saw it. The long dives (after fluking) were usually not longer than 3 minutes. Several times the flukes were noted to be at "hard dive" just before disappearing. The whale's breath was very fetid, as we have now and again noticed with this species. We supposed, but without direct evidence, that it was feeding; its track was very erratic in detail while making good a general northwesterly course.

Unfortunately the water was turbid, so that even from the air it was usually not easy to spot the whale more than about a fathom under water. Robert G. Weeks watched a pair of these *Megaptera* from the air on 30 October: one fluked and went down out of sight; the other passed the diving point, turned down through 90° and hung head down with flukes awash and the white belly showing; the position or activity of the flipper was not noted, because of the turbidity of the water.

The earliest we ever saw our whale was 0930, but usually the first contact was near 1300 to 1400. We ordinarily met it about 4 sea miles southeasterly of Fletchers Neck, in about 15 to 40 fathoms; it then continued to the northwestward until the water depth decreased to about 6 fathoms or a little less, when it would turn back to sea, sometimes skirting the reefs a while first (Fig. 1). On two occasions it came in to the buoy south of Fletchers Neck and then turned right and coasted along near the 8-fathom line until it was near Wood Island, when it turned back offshore, to the southeast. Another time it continued on around to the north of Wood Island, past the entrance buoys for Saco River. We never traced it much later than 1600, since the early darkness obliged us to head for our harbor nearly 10 miles away as soon after 1530 as possible. Our small vessel was weatherbound on four days, but on two of these we managed to spot our whale from Fletchers Neck as it came in between us and the offing of Wood Island, right on schedule.

Of these ten days, we saw the *Megaptera* on seven; on two of the unproductive days we were weatherbound, and on the other we found no sign of *Megaptera* in the area, only a 60-foot *Balaenoptera physalus* (finback); this was the only day we saw one of these. On six of the *Megaptera* days, we found the whale in about the same place in the early afternoon; on the other we had it from 0930 to about 1100. To sum up, the same whale swam through the same area at the same time on 29 and 30 October and on 2, 4, 6 and 7 November. We were struck by the persistence of this routine and its consistency with the clock. Had the whale kept a constant relation to the tides which one might suppose would influence its prey, it would be easier to explain; but had this been the case, by 7 November the whale should have been about seven hours later than on 29 October. We regret that we were not able to outstay the whale in this vicinity.

During January 1954 the senior author noted that *Tursiops truncatus* (bottle-nosed porpoise) followed a tidal routine at St. Augustine, Florida. At low water slack, the bay teemed with porpoises; as the tide rose, they went up the rivers and creeks with it, so that at high water slack scarcely a porpoise was left in the bay, but by low tide they had come back and occupied the bay again. This routine was independent of the clock and was presumably largely a response to the tidal movement of prey. We do not know whether our Fletchers Neck *Megaptera* was feeding but, whatever it was doing, it evidently followed the sun and not the moon.—WILLIAM E. SCHEVILL AND RICHARD H. BACKUS, *Woods Hole Oceanographic Institution, Woods Hole, Massachusetts.* *Received 1 May 1959.*

[Contribution 1040 from the Woods Hole Oceanographic Institution.]

GAITS OF THE GIRAFFE AND OKAPI

The walking gait of the giraffe is usually considered as unique among mammals. The giraffe walks or "paces" by lifting the two limbs on the same side of the body approximately at the same time, rather than by moving alternate legs on either side in the manner of the horse and other mammals. A. B. Howell (SPEED IN ANIMALS, Univ. Chicago Press, 1944, p. 66) concludes that the unusual gait of the giraffe is necessary to keep the long legs of the animal from interfering with each other. Because of the giraffe's height, its lateral or transverse inertia is great enough to counteract the disruptive "pacing" walk which would prove too disturbing to the stability of a smaller animal.

On a visit to the Bronx Zoo in New York, I noticed that the okapi also walked in the same peculiar manner as the giraffe. The okapi superficially resembles other artiodactyls far more than the giraffe. Its neck is relatively short and its forelegs are slightly shorter than its hind legs, unlike the giraffe whose forelegs are decidedly longer than its hind legs (Forsyth Major, Proc. Zool. Soc. London, 1902, 73–79).

Despite their difference in build, the okapi and the giraffe are closely related, both from an anatomical (Colbert, Jour. Mamm., 19:47–64, 1938) and from a serological point of view (Van den Berghe, Bull. Classe Sci., Ser. 5, 30:239–244, 1944). The okapi and the giraffe are believed to have developed during the middle Pliocene from a short-necked common ancestral giraffid (Colbert, Amer. Mus. Nov., No. 800, 1935).

The gait of the giraffe, therefore, although admirably suited to the shape of the animal, seems to have been developed in the giraffid line as far back as the Pliocene, when the giraffids were not distinguished by their long neck and long legs.—ANNE INNIS DAGG, *108 Driveway, Ottawa, Ontario.* *Received 14 April 1959.*

MAMMAL SKULLS RECOVERED FROM OWL PELLETS IN SONORA, MEXICO

On 28 November 1958, E. Lendell Cockrum, David Cockrum and Bruce Hayward were checking caves and mine tunnels for bat concentrations in the low mountains about 1 mile west of Mayterrena, Sonora, Mexico, which is approximately 10 miles north of Empalme. This trip was made as a part of the investigations of the biology of the bats of the southwest, supported by National Science Foundation Grant G–5209. The mountains are about 1000 feet above the coastal plain. Vegetation on the slopes consists of dense stands of cholla, ocotillo, prickly pear and mesquite. A barn owl (*Tyto alba*) was flushed from one of the fissure-type caves checked. Two plastic "deep freeze" bags (approx. 1 liter volume each) were filled with pellets from beneath the roost and brought back to the University of Arizona.

Our method of examining the dry pellets consisted of crumpling them to recover the larger, complete skulls. The remaining material was then placed in a large-mouthed gallon jar which was partially filled with a weak detergent solution. The pellets were soaked for about 15 minutes and the remaining lumps were gently crumpled to displace any bones present. The jar was then completely filled with water which floated the hair to the surface. This floated material was checked for additional bones, which were saved. A gentle stream of water was introduced into the jar, floating out the remaining hair and dirt. As soon as the water ran clear, it was decanted and all the skeletal material at the bottom of the jar was removed and dried. Additional work has shown that feathers should be removed before soaking. Complete bird bones will float to the surface with the hair, and can be removed at that time. The skimmed-off layer of hair can be dried for further identification.

An analysis of the cranial material collected in this manner revealed the following 234 mammals: *Mus musculus*, 117; *Notiosorex crawfordi*, 35; *Perognathus* sp., 13; *P. flavus*, 12; *P. baileyi*, 2; *Sigmodon hispidus*, 25; *Reithrodontomys burti*, 5; *R. burti*?, 7; *Reithrodon-*

tomys sp., 10; *Dipodomys merriami*, 2; *D. merriami*?, 2; *Peromyscus eremicus*, 2; and *Macrotus californicus*, 1 left dentary.

Several items appear worthy of note. (1) no bird bones or feathers were recovered. (2) *Mus musculus* was as abundant as all other species combined. Hayward set a line of snap traps in the vicinity of the cave about one month later and caught 26 *Peromyscus* and no *Mus musculus*. It appears that *Mus* is an easier prey species, or the owl showed preferential selection to a large degree, since the nearest buildings are at least ½ mile from the owl roost. (3) Lange (Amer. Midl. Nat., 61: 106, 1959) cites the first record of *Notiosorex* in Sonora as 15 mi. S. Nogales, Sonora. Our recoveries then extend the range nearly 240 miles farther south. Future collecting will probably show that this species has a continuous range down the west coast of Mexico. (4) The occurrence of *Reithrodontomys burti* in our sample extends its known range about 75 miles south along this coastal plain (Hooper, Mus. Zool. Univ. Mich., Misc. Publ. 77, 1952). (5) The appearance of a single dentary bone of *Macrotus californicus* indicates possible predation by barn owls. Since the bone was greatly weathered, it is possible that it was extraneous to the owl pellets and was included at the same time that the pellets were collected.

Thanks are due to Emmet T. Hooper who verified the identification of the species of *Reithrodontomys*.—Gordon VR. Bradshaw and Bruce Hayward, *Dept. of Zoology, Univ. of Arizona, Tucson.* *Received 30 March 1959.*

A CAGING ARRANGEMENT FOR SMALL MAMMALS

Conventional screen and metal cages are often used for wild animals because of their availability, but they may suffer various disadvantages including difficulty of access without loss, abrasion to the feet, fouling of screen by droppings, exposure of sensitive species to drafts, disturbance or direct light and, not least, the very substantial cost of a rust-proof unit. The use of a glass acquarium can meet some of these problems, but these are too heavy, clumsy and breakable for multiple use. Commercial plastic cages meet some requirements but not others.

A system which we have found very successful over the last two years involves the use of plastic window boxes.* These units are very light but have a fiber-glass matrix which improves strength and resistance since they are designed to carry a heavy load of dirt. Because of their light weight and mountable design they may be hung from a simple support, in contrast to the bulky angle-iron frames often employed. They are opaque, shielding the animals from direct exposure or disturbance.

The boxes come provided with hangers which allow rapid mounting and demounting (Fig. 1). A cover is constructed of expanded metal, bent to engage the rolled edge of the box. It may be made of stainless steel for permanence, but we have found the much less expensive galvanized steel quite satisfactory since it is never fouled. The rolled edge of the cover is notched to engage the mounting hangers. This fixes the cover in relation to the hangers so that the box may be withdrawn from the lid for access, without removing it from the hangers.

In a convenient arrangement the hangers are bolted in pairs on a simple pipe "U", which may in turn be mounted on a wooden base or fastened to an integral pipe base, and provided with casters. The figured rack, which provides rather generous clearance between units for ease of observation, carries a dozen units in a floor space of 4 square feet. Closer spacing with the water bottles mounted at the end might hold 20 units in the same floor area. Because of the lightness of the boxes the rack is remarkably stable in view of its height (78 in.) and small wheel base (24x24 in.). This allows it to be easily moved for access and servicing and a group of frames may be pushed into the end of a room without aisles, if space is at a premium.

*Plastic Products Corporation, P. O. Box 857, Cleveland 22, Ohio.

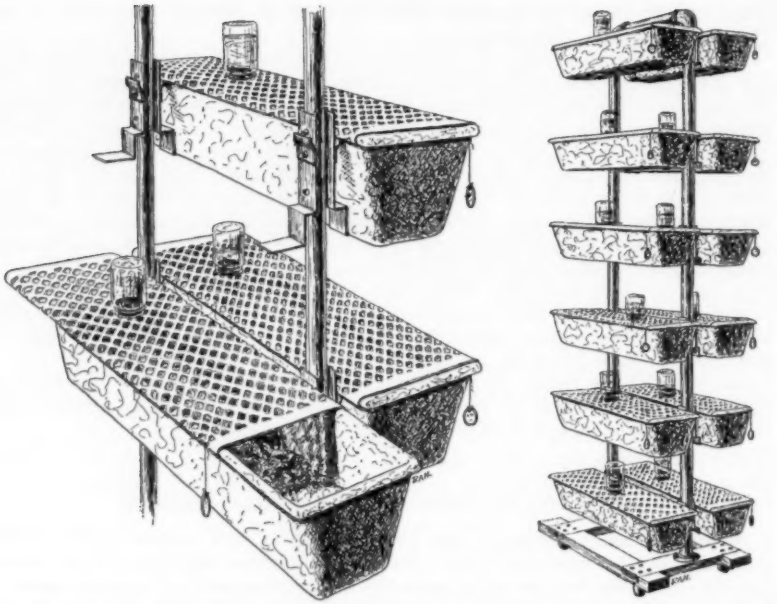


FIG. 1.—Detail of construction showing mounting of hangers and sliding lid, and overall view of rack with complete frame and base.

In cleaning, the occupants are simply transferred to a fresh unit. Capture is relatively easy and there is little danger of loss. The smooth-tapered configuration of the boxes facilitates cleaning, and since the tops do not get dirty they may be exchanged directly. A dozen clean boxes are conveniently kept in reserve. The units may be easily disassembled for storage and, since the boxes nest, they occupy little space in this condition. Beyond the boxes and hangers, all materials are common supplies and the construction can be accomplished by relatively unskilled labor. We have used 24-in. boxes but they are also available in 18, 30 and 36-in. lengths. Use of a central spacer provides two separate compartments in each unit. Colored boxes may be used for coding according to species or feeding regime.—PETER MORRISON, *Depts. of Zoology and Physiology, Univ. of Wisconsin, Madison.* *Received 9 January 1959.*

AN ACCURATE RECORDER FOR ANIMAL ACTIVITY

The continuing interest in the study of "24-hour" rhythms of animal activity (Aschoff, Naturwiss., 41: 49–56, 1954; *ibid.*, 42: 569–575, 1955) has suggested the need for a simple impulse counter for registering both the total amount of activity per unit time and the temporal occurrence of this activity. The observation that the endogenous "inner clocks" of some animals are accurate to within a few minutes per day (Rawson, pp. 791–800 *in* Photoperiodism and Related Phenomena in Plants and Animals, AAAS, Washington, D.C., 1959) indicates that summing units of activity (e.g., turns of a running wheel) over a 4-hour or even 1-hour period do not adequately match the precision of the biological material. Further, the recording of a number of animals simultaneously requires an excessive amount of labor if even hourly levels of activity must be plotted and graphs drawn for each animal

each day. With the apparatus shown in Fig. 1, the animal essentially constructs its own graph of activity.

A synchronous motor of the "Telechron" type responds to alternating current by a fixed degree of rotation of the armature with each cycle. This motor can also be driven by alternating positive and negative pulses of direct current (Fig. 1*A*). The DC pulses are delivered through a single-pole double-throw switch activated by the recording cage (run-

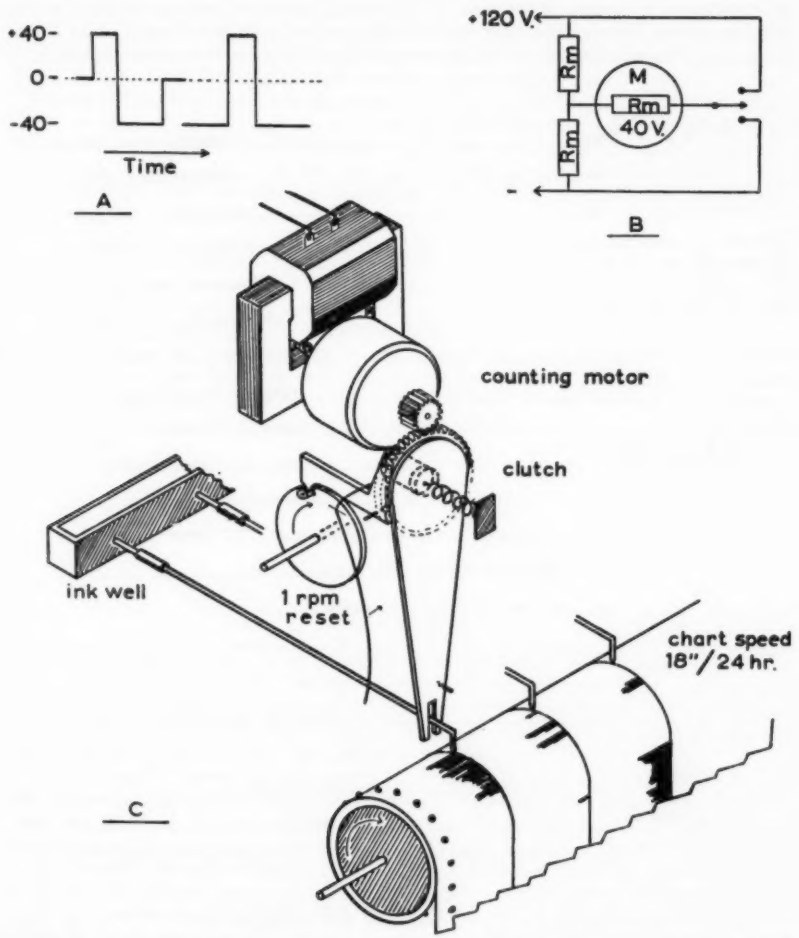


FIG. 1.—Recorder for activity studies, schematic. *A*: Two pulse forms which will "step" the motor; *B*: electrical circuit in which Rm equals the DC resistance of the 110-V AC motor; *C*: basic mechanical structure of the recorder with synchronous chart and reset drive motor and gear trains omitted.

ning wheel, spring-mounted cage, or perch in a bird cage). The circuit given in Fig. 1*B* provides a uniform load to the DC power supply regardless of the position of the switch. The arrangement of the motor as a pen drive is shown in Fig. 1C. A motor rated at 1 rpm will rotate 10° for each 100 double pulses. This motion is transmitted to a recording pen which makes a lateral excursion on a record chart. The clutch mechanism allows periodic resetting of the pen element to the base line. Convenient pen excursions for the rate of counting in any particular process may be controlled by choice of the reset interval. The resulting solid graph (Fig. 2) gives as its envelope the rate of the event (e.g., revolutions per minute) as a function of the time of day. In the present apparatus, 10 pen elements write on a single 12-inch-wide chart. Individual record strips 18 inches long (= 24 hours) are cut from the chart and pasted on cardboard sheets which are then photographed.

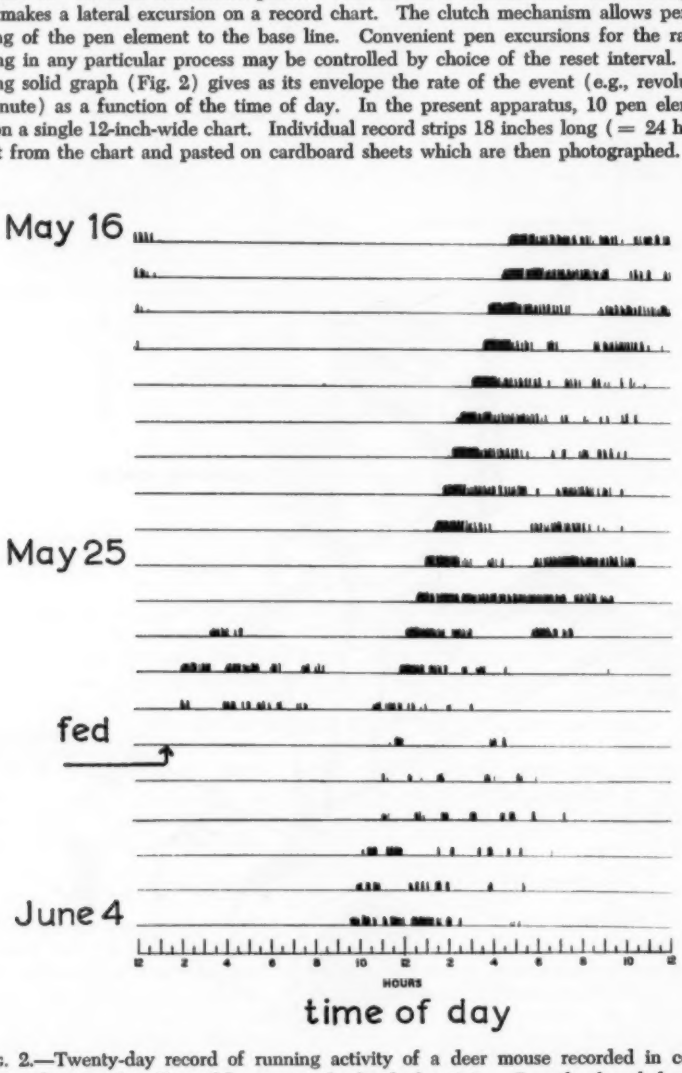


FIG. 2.—Twenty-day record of running activity of a deer mouse recorded in constant darkness showing the effect of hunger on the level of activity. Length of each horizontal line represents 24 hours. Maximum vertical pen excursion equals 100 revolutions per minute. Two weeks' supply of food presented where "fed" indicated.

The record of a male white-footed mouse, *Peromyscus leucopus*, in Fig. 2 shows that the period of this individual's endogenous rhythm is 23 hours 35 minutes, that is, it becomes active 25 minutes earlier each day. The accurate measure of the period is given by the time of onset of activity. Total running activity of the animal is quantitatively represented by the area of the solid graph so the effects of experimental conditions can be simply measured by cutting the dark areas from photographic prints and weighing them on a chemical balance. In the example given, the running activity of the mouse for six days prior to feeding (hunger) was 2.4 times greater than the activity measured following the addition of food to the cage (cf. Wald and Jackson, Proc. Natl. Acad. Sci., 30: 255–263, 1944). Although the animal ran during its normally inactive period when hungry (Fig. 2, May 27–29), it continued the original period and phase of the rhythm when fed. The maximum rate of running for this animal was 100 revolutions per minute.

The lack of mechanical wear in this recording system is of primary importance as 50,000 pulses are often counted in a single day. The apparatus described has been in continuous operation for two years without noticeable wear in the counting mechanism. The recorder has the additional advantage of low cost allowing the assembly of many channels on a limited budget. That the animal itself performs the drudgery of constructing the detailed activity graphs is an important feature of this system.

The difficulty of machining the clutch assembly can be avoided by using a reversible "Telechron" motor which has two field coils. The motor is stepped in one direction by applying DC pulses to one coil and reset by applying 60-cycle current to the other. This permits a fixed linkage between motor shaft and pen. The apparatus can then be easily assembled from commercially available components.

The apparatus was constructed at Harvard University. This study was supported, in part, by research grant RG–5378 from the National Institutes of Health, U.S. Public Health Service and grants 57:210 and 57:405 from the Wisconsin Alumni Research Foundation.—KENNETH S. RAWSON, *Dept. of Biology, Swarthmore College, Swarthmore, Pa.* *Received 8 January 1959.*

REVIEWS

Harrison, David L. FOOTSTEPS IN THE SAND. Ernest Benn Ltd., London. 353 pp., illus. 1959. 25 shillings.

This is an interesting and well-written book about the experiences of a young Royal Air Force Medical Officer, interested in natural history, detailed to the Middle East countries for his tour of duty.

Dr. Harrison has shown unusual ability in observing the scarce, though varied wildlife and peoples of the Trucial Oman, Saudi Arabia, Jordan and Iraq. His duties carried him from the "hundred days of hell" in the Oman to the cool, forested mountain slopes of northern Iraq.

As a result of this tour of duty, Dr. Harrison has produced a delightful, popular book plus a number of technical papers published in scientific journals listing the known kinds of mammals and the localities from which they came as well as describing some of the new forms obtained.

It is hoped that Medical and Dental Corps Officers of all Armed Forces can read this book and realize the relaxation and enjoyment that can be had in collecting specimens and observing the habits of animals in remote posts to which they are assigned.—HENRY W. SETZER.

Cowles, Raymond B. ZULU JOURNAL: FIELD NOTES OF A NATURALIST IN SOUTH AFRICA. Univ. California Press, Berkeley and Los Angeles. 267 pp., illus. 5 October 1959. Price, $6.00.

In this book, Dr. Cowles, Professor of Zoology at the University of California, relates his experiences in South Africa, mainly in the Hluhluwe Valley in Natal, over various periods from the end of the last century to the early 1950's. The author's first impressions, as son of an early missionary family, were of huge herds of game animals wandering across a country unspoiled by the hands of man, and of forests not as yet destroyed by civilization. He describes the changes he observed in the twenties and the startling new Africa of the fifties.

His topics range from discussions of the protective coloration of the skin of the negro to the parasitism of the honey guide, from termites to African superstitions. Of particular interest to mammalogists will be the first-hand observations and comments concerning a host of mammals, both large and small. African rats, shrews and bats are treated as well as the better-known rhinoceros, zebra, wildebeest and bushbuck.

With the rapid changes occurring in Africa today, we are fortunate that Dr. Cowles has been able to capture the feeling, and many of the scenes, which are vanishing or are already gone forever. The book is natural history at its best, and contains the same qualities of scientific accuracy combined with readability found in the works of J. Henri Fabre, Ernest Thompson Seton and other great naturalists.—JOHN L. PARADISO.

Leopold, A. Starker. WILDLIFE OF MEXICO: THE GAME BIRDS AND MAMMALS. Univ. California Press, Berkeley and Los Angeles. Pp. xiii + 568, 194 figs., 2 color plates. 23 November 1959. Price, $12.50.

Mexico is a land of varied topography, diverse habitats, and a rich fauna representing a combination of Nearctic and Neotropical elements. Except for a few sporadic accounts, the fauna has been largely neglected by zoologists since the days of the Conquistadores. Land use has greatly altered the environment since that time. Agriculture and grazing have encroached upon previously wild areas; vegetation, soil and water have been altered since man's occupation; and accompanying changes have taken place in the abundance and distribution of the animals. In the past several decades there has developed among biologists, particularly of the United States, an increased awareness of and interest in the fascinating fauna of Mexico. Repeated expeditions have gone southward, numerous technical accounts have been published. But this is the first comprehensive treatment of the birds and mammals directed at the people of Mexico interested in natural history, hunting, or conservation. (A Spanish translation is planned for the near future.)

Preparation of this work has taken over twelve years. An initial two years of field work, sponsored by the Pan American Union, began in 1944. Since then the author has made repeated trips of shorter duration to all parts of Mexico, serving to fill in many of the remaining gaps. Besides specimens, extensive notes and many photographs were accumulated. These data are here supplemented with information from the literature and from various museums.

The scheme of the book is simple and straightforward. Part I deals with The Wildlife Resource and Its Management, with chapters on the physiography and vegetation types, land use, utilization of wildlife, and present and future programs for wildlife conservation. A strong case is made for the establishment of a system of great natural preserves, and stimulating suggestions are offered for formulating a program of wildlife conservation based on ecological principles. Part II treats in detail over 70 species of game birds, with descriptions, portraits, range maps and other particulars. Part III is a similar treatment of 83 species of mammals. Inasmuch as nearly all Mexican mammals are sometimes taken for human use, arriving at a list of the "game" species was a problem. Finally, those enumerated in the 1954 version of the Mexican Game Law were adopted, with some exceptions. The result is a guide to practically all the Mexican mammals larger than a

cottontail, and a few smaller ones such as the weasel, tree squirrels and volcano rabbit. The omission of the smaller ground squirrels, mice, shrews, bats and others will be regretted by many, but apparently was inevitable. Each species is described and illustrated, its range mapped, names listed, habits, natural history and measurements given. Hunting methods and eating qualities are indicated for many. The Mexican Game Law and hunting regulations are reproduced in the Appendixes; a lengthy Bibliography and an adequate Index complete the volume.

The book is profusely illustrated with photographs of animals and habitat types and with many maps. For nearly every species Charles W. Schwartz has provided full-page drawings, including skull and various anatomical details (in the case of mammals) as well as his customary lifelike portraits. Additional sketches decorate chapter headings and other spots, and two color plates (of grizzly and ocelot) add to the over-all effect. This handsome and authoritative volume answers a long-felt need and will certainly be welcomed by hunters, naturalists and conservationists, as well as by professional biologists.—RICHARD H. MANVILLE.

Matthiessen, Peter. WILDLIFE IN AMERICA. The Viking Press, New York. 304 pp., illus. 19 October 1959. Price, $10.00.

In the preface to the 1872 edition of *The Oregon Trail,* Francis Parkman wrote that "A time would come when those plains would be a grazing country, the buffalo give place to tame cattle, farmhouses be scattered along the water courses, and wolves, bears, and Indians be numbered among the things that were." How prophetic were these words we know all too well. Matthiessen here paints the background and sketches the course of these changes, in words that are provocative, engaging, and often poetic. This is an historical account of white man's effects on the native American fauna. It is concerned chiefly with the recently extinct, rare, declining or endangered species, including 27 fishes, 8 amphibians, 9 reptiles, 57 birds and 42 mammals—a sad testimony to human ignorance, indifference and greed.

Not only a sympathetic understanding, but a vast amount of research went into this writing, attested to by the parade of naturalists and explorers, politicians and conservationists, painters, writers and others that briefly enter the story here and there. From early colonial times, when the fur trade surpassed in importance the commerce in timber and fish—the beaver "commenced its decline as early as 1638, when to its misfortune the compulsory use of it in the manufacture of hats was decreed by King Charles II"—we follow the course of conservation up to the present clamor for the introduction of exotic species. From the time in 1630 when "the Massachusetts Bay Company established the first New World bounty system with the payment of one penny per wolf" we trace the hazards to wildlife up to our current use of chlorinated hydrocarbons as pesticides. The sea mink, Dawson caribou and Merriam elk succumbed to tinkering by humans; the manatee, key deer and Kaibab squirrel became so scarce as to require stringent protection; the sea otter, fisher, bison and gray whale, once almost given up as lost, responded to help just in the nick of time. The fate of many others hangs in the balance.

In all fairness, the author is at pains to point out that extinction is a natural event, "enacted on earth so many times before [man] came, and certain to continue when his own breed is gone." Many of our vanishing forms are "senile species, better suited to other ages, other climates, and too old to change." They are doomed, with or without man's intervention. But man is hastening their demise; he is the most adaptable of all and, in competition, "less resourceful creatures have no choice but to make room for him during his stay on earth." The fact remains that "until man, the highest predator, evolved, the process of extinction was a slow one. No species but man, so far as is known, unaided by circumstance or climatic change, has ever extinguished another, and centainly no species has ever devoured itself, an accomplishment of which man appears quite capable." Meanwhile, he has produced a landscape where "today's voyager, approaching our shores through the oiled waters of the coast, is greeted by smoke and the glint of industry on our fouled sea-

board, and an inland prospect of second growth, scarred landscapes, and sterile, often stinking, rivers of pollution and raw mud, the whole bedecked with billboards, neon lights, and other decorative evidence of mankind's triumph over chaos. In many regions the greenwood not converted to black stumps no longer breathes with sound and movement, but is become a cathedral of still trees; the plains are plowed under and the prairies ravaged by overgrazing and the winds of drought. Where great, wild creatures ranged, the vermin prosper."

A map of the continent pinpoints most areas referred to in the text. An Introduction is contributed by Richard H. Pough. The Appendixes list the vertebrate species concerned and give a chronology of legislation affecting wildlife, starting about 1616. Documentation is provided by Reference Notes and an extensive Bibliography. A good Index is included. The book's value is greatly enhanced by the inclusion of lavish illustrations. There are 16 pages of documentary photographs and drawings from historical sources and eight full-color plates by the Audubons, father and son, Alexander Wilson, Mark Catesby, Titian Peale and Louis Agassiz Fuertes. There are drawings on nearly every page from the gifted pen of Bob Hines depicting accurately and artistically nearly all the creatures discussed. Two of Jay N. "Ding" Darling's most telling cartoons are reproduced. The end papers are decorated with Indian designs copied by George Catlin. Albert Bierstadt's *The Buffalo Trail* adorns the dust jacket. Altogether, this is a beautiful book, eloquently written, and a distinct and unique contribution to the history of wildlife in North America. —Richard H. Manville.

Schwartz, C. W. and E. R. Schwartz. The Wild Mammals of Missouri. Univ. Missouri Press and Missouri Conservation Commission. 341 pp., illus. 1959. Price $5.95.

Charles and Elizabeth Schwartz are internationally known for their award-winning films "Bobwhite Through the Year," "Cottontail" and "A Way of Life." Their book *Game Birds of Hawaii* was judged the best publication in wildlife and ecology in 1949 and 1950 by the North American Wildlife Society. This book, *The Wild Mammals of Missouri*, is a splendid addition to their impressive list of achievements. While the book "is designed as a guide to the identification of the wild mammals of Missouri and as a reference to facts about their lives," it accomplishes far more than these aims and is unquestionably the best book that has been published in this field.

An introductory chapter discusses general characteristics of mammals, where mammals live, size of mammals, how mammals are named, the mammals of Missouri, how to identify mammals by keys, a key to orders based on whole adult mammals, a key to orders by skulls, how to identify mammal tracks and general references about mammals. A great deal of time and thought has obviously been spent on this chapter. The material is presented briefly and in relatively simple terms, yet there is enough vocabulary and detail to prepare a non-biologist for the main text. The section on identification of mammal tracks is too brief to be very useful, but most of the material in this chapter is informative and well presented. The success of the introductory chapter is partly due to the way in which the authors have used transitional sentences and ideas to carry the reader from one level of information to the next. For example, the discussion of teeth as a characteristic of mammals includes a few pertinent facts about the structure and formation of teeth and then leads to consideration of types of teeth, dental formulas, variations in dental formula, and how these variations are related to feeding habits, tooth function and classification. Topics such as mammalian reproduction, which are often omitted or are only given casual treatment in other guides, are thoughtfully included.

The main body of the text is devoted to accounts of each of the 62 species of mammals known to occur in Missouri. A short section at the end of the book deals with five species which formerly occurred there in historic times, and 13 species which possibly occur in Missouri but have not been recorded. In the presentation of each order of mammals there is a short description of the characteristics of the order followed by keys to species by whole

adult animals and skulls. Each species account is divided into sections dealing with its name, description, distribution and abundance, habitat and home, habits, foods, reproduction, adverse factors, and management and control. A short selection of references appears at the end of each account.

The information in each of the species accounts is accurate and informative and well presented. The section dealing with the name of each species includes the origins and meanings of the scientific and common name. The description includes gross features and diagnostic characters, color, measurements of body and skull, teeth and skull, sex criteria, age criteria, glands, and voice and sounds. The discussions of age criteria are especially noteworthy. Current information on a variety of age criteria is included, along with excellent illustrations wherever appropriate. In the discussions of general habits, the authors have avoided the common tendency to pepper the text with small bits of unrelated facts, and have provided useful information presented in readable style. The distribution of each species in Missouri is described briefly, and there is a distribution map showing the range of each species in North America. There are some inaccuracies in details of the range maps, but these are minor for the most part. The sections on reproduction are excellent. They include data on the mating period, mating behavior, gestation period, date of birth of the earliest litters, litter size, size of young and development. The least useful sections are those on control and management. The authors feel that "the balance of nature" is the best control in most instances, and the result is needless repetition of the advantages of natural control and very little useful information about artificial control. The selection of references at the end of each species account usually numbers ten or less, but these give fairly broad coverage with well-chosen papers.

The illustrations, which number almost 400, are an outstanding feature of the book. In addition to sketches of tracks, nests, runways and ecological events that are pertinent to the text, the book is profusely illustrated with a variety of attractive sketches that are not essential but, nevertheless, add to the beauty of the book.

The most valuable illustrations are the full-page (8x11) plates that accompany each species account. Readers of the *Missouri Conservationist* will recognize some of these plates, which appeared monthly from July 1953 through September 1957. The combination of useful detail and artistic quality in these drawings makes them unique among mammal illustrations —they can only be described with superlatives. Each plate includes a pencil sketch of an adult of the species in a typical posture; detailed drawings of the fore and hind feet; top, side and bottom views of the skull and teeth with diagnostic features labeled; and magnified views of special, diagnostic characters. Special features of the dentition of some species are shown in detail. The head of each species of bat is figured in profile, showing the tragus and other diagnostic features. Structures such as the fossorial limbs of the mole, cheek pouches of different rodents, and many other unique characteristics are illustrated.

This book has very few shortcomings and succeeds admirably in achieving the aims set for it, but the authors seem, at times, to make unnecessary concessions to the amateur. For example, they try to avoid the terms "vole" and "lemming" in common names, presumably because these are not familiar terms. Thus *Microtus ochrogaster* is called the Prairie Meadow Mouse and *Synaptomys cooperi* the Southern Lemming Mouse. Lagomorphs are referred to as the "hare-shaped mammals." Any self-respecting pika is certain to object to this insult! There is no reason why the common names accepted by the American Society of Mammalogists could not be used, with alternative names given in the text. A few of the interpretations of scientific names also seem more provincial than necessary. The species name of *Zapus hudsonius* is presumed to refer to Hudson Bay, the type locality. The specific name of the black bear, *Euarctos americanus*, is supposed to refer to *eastern* North America, since this is the locality referred to in the original description. Surely these are unnecessary restrictions in meaning. It might be more useful to say that they refer to geographic areas or life zones, since the meanings given in this book are not generally applicable to other species with these names.

An increasingly common usage in scientific texts, and one which the authors have adopted in this book, is the substitution of numbers for words. Thus, ". . . 2 or more coyotes may chase the animal in relays (p. 251)"; "Female wood rats have 2 pair of teats in the groin region (p. 198)"; or, the nest ". . . has 1 or more entrances (p. 199)." There is no real justification for this device—this reviewer found it more irritating than helpful.

These few criticisms are directed at only a small part of an excellent book, and they should not be allowed to detract from the praise that is due the authors and their publishers. There has obviously been a close union of the exceptional talents of the authors and a desire for service on the part of the University of Missouri Press and the Missouri Conservation Commission, in order to publish a book of this quality at such a low price. It has set a standard which future mammal guides will be hard pressed to match, and deserves wide reading among amateur naturalists and professional mammalogists.—RICHARD S. MILLER.

RECENT LITERATURE

(Prepared by the Committee on Bibliography)

ADAMS, WILLIAM H. Deer are plentiful in Alabama! Alabama Conservation, 31 (2): 23. August-September 1959.

AELLEN, V. Contribution à l'étude de la faune d'Afghanistan. 9. Chiroptères. Rev. Suisse Zool., 66 (21): 353–386. August 1959.

ALTMANN, MARGARET. Patterns of social behavior in big game. Trans. 21st North Amer. Wildlife Conference, pp. 538–545. 1956.

ANDERSON, SYDNEY. Distribution, variation, and relationships of the montane vole, Microtus montanus. Univ. Kansas Publ., Mus. Nat. Hist., 9 (17): 415–511, illus. 1 August 1959.

ANDERSON, SYDNEY, AND WILLIAM N. BERG. Extension of the known range of the cotton rat, Sigmodon hispidus, in New Mexico. Southwestern Naturalist, 4 (1): 40–42. June 1959.

ANONYMOUS. Bat bite confirmed cause of human rabies death. California Vector Views, State Dept. Public Health, 6 (3): 20. March-April 1959.

ANSELL, W. F. H. Further data on Northern Rhodesian ungulates. Mammalia, Paris, 23 (3): 332–349. September 1959.

APPELMAN, F. J. Ein Wort über *Ceratotherium simum cottoni*. Zool. Garten, 24 (3–4): 284. 1959.

BADER, ROBERT S. The reported occurrence of *Reithrodontomys* in the Pleistocene of Florida. Jour. Paleontol., 33 (5): 968. September 1959.

BARKER, ELIZABETH. Canine teeth in white-tailed deer. Blue Jay, Saskatchewan Nat. Hist. Soc., 17 (3): 125. September 1959.

BECKER, KURT. Die Populationsentwicklung von Feldmäusen (*Microtus arvalis*) im Spiegel der Nahrung von Schleiereulen (*Tyto alba*). Zeitschr. Angewandte Zool., Berlin, 45 (4): 403–431. 1958.

BEELER, D. A., D. A. BENSON, AND W. M. LANGILLE. Mineral analyses of livers and kidneys of moose (*Alces americana*). Jour. Wildlife Management, 23 (3): 356–358. July 1959.

BELIAJEVA, E. I. Sur la découverte de Rhinoceros tertiaires anciens dans la Province Maritime de L'U.R.S.S. Vertebrata Palasiatica, 3 (2): 81–91, illus. June 1959. (New: *Eotrigonias borissiaki.*)

BELKOVICH, V. M. On the mechanism of colour variation in Delphinapterus leucas Pall. Doklady Akad. Nauk. SSSR, 127 (4): 928–933. August 1959.

BEMMEL, A. C. V. van. Birth of *Cebus capucinus hypoleucus*. Zool. Garten, 24 (3–4): 246–247, illus. 1959.

BERNARD, J. Note sur la période de reproduction du renard (*Vulpes vulpes* Linné, 1758) dans le Luxembourg belge. Säugertierk. Mitteil., 7 (3): 110–113. 1 August 1959.

BERNARD, J. Note à propos du genre *Arvicola* Lac. en Belgique. Mammalia, Paris, 23 (3): 369–373. September 1959.

BIRUKOW, GEORG. Statischer Sinn. Handbuch der Zoologie, Berlin, Band 8, Teil 8, Beitrag 4 (Lieferung 23), pp. 1–40. September 1959.

BLOCK, GUY DE. Sur une maternité de sérotines *Eptesicus serotinus* près de Wavre (Brabant). Mammalia, Paris, 23 (3): 374–377. September 1959.

BRASS, L. J. Results of the Archbold Expeditions. No. 79. Summary of the Fifth Archbold Expedition to New Guinea (1956–1957). Bull. Amer. Mus. Nat. Hist., 118 (1): 1–70, pls. 1–8. 13 July 1959.

BRUNNER, GEORG. Das Schmiedberg-Abri bei Hirschbach (Oberpfalz). Pal. Zeit., 33 (3): 152–165, illus. July 1959.

CAHALANE, VICTOR H. A biological survey of the Katmai National Monument. Smithsonian Misc. Coll., Washington, 138 (5): 1–246, pls. 1–17, map. 20 August 1959.

CARTER, T. DONALD. The mountain nyala. Animal Kingdom, New York Zool. Soc., 62 (4): 118–123. August 1959.

CHOW, MIN-CHEN, AND YU-XUAN XU. Indricotherium from Hami Basin, Sinkiang. Vertebrata Palasiatica, 3 (2): 93–96, illus. June 1959.

CHOW, MINCHEN. A new arctocyonid from the Upper Eocene of Lushih, Honan. Vertebrata Palasiatica, 3 (3): 133–138, pls. 1–2. September 1959. (New: *Paratriisodon, P. henanensis.*)

CONNOR, PAUL F. The bog lemming *Synaptomys cooperi* in southern New Jersey. Publ. Mus. Michigan State Univ., Biol. Ser., 1 (5): 161–248, pls. 1–4. 24 July 1959.

CREISLER, JOE. New state legislation on dead marine mammal disposal. California Vector Views, State Dept. Public Health, 6 (5): 32. July 1959.

CURRY-LINDAHL, KAI. Die Freilichtmuseum "Skansen" in Stockholm. Natur und Land, 44 (12): pp. 1–8 (of reprint). 1958.

CURRY-LINDAHL, KAI. Landskapets förändringar och faunen. Sveriges Naturs Årsbok, 1959: 87–108, 8 pls. 1959.

CURRY-LINDAHL, KAI. Skogens vilda djur. Svenska Turisföreningens Årsskrift, 1959: 177–206, illus. 1959.

CUTTER, WILLIAM L. Notes on some mammals from northern Texas. Southwestern Naturalist, 4 (1): 30–34. June 1959.

DANDELOT, PIERRE. Note sur la classification des cercopithèques du groupe *aethiops*. Mammalia, Paris, 23 (3): 357–368, illus. September 1959.

DANILOVA, E. I. An attempt to reconstruct the foot of Mongolotherium plantigradum Flerow by its skeletal remains. Zool. Zhurnal, 38 (7): 1069–1080. July 1959. (In Russian, with English summary.)

DASMANN, RAYMOND F. Fluctuations in a deer population in California chaparral. Trans. 21st North Amer. Wildlife Conference, pp. 487–499. 1956.

DAVIS, JOSEPH A., JR. A giant pouched rat in the zoo. Animal Kingdom, New York Zool. Soc., 62 (4): 124–125, illus. August 1959. (*Cricetomys.*)

DAVISON, H., AND C. P. LUCK. Chemistry and rate of turnover of the ocular fluids of the bush baby *Galago crassicaudatus agisymbanus*. Jour. Physiol., London, 145 (2): 433–439. March 1959.

DONNER, J. J., AND B. KURTÉN. The floral and faunal succession of "Cueva del Toll," Spain. Eiszeitalter und Gegenmart, 9: 72–82, illus. 15 July 1958.

DUNTON, SAM. Mambo keeps cool. Animal Kingdom, New York Zool. Soc., 62 (4): 111–113, illus. August 1959. (Lowland gorilla.)

EHLERS, KURT, WERNER SIERTS, AND ERNA MOHR. Die Klappmütze, *Cystophora cristata* Erxl., der Tiergrotten Bremerhaven. Zool. Garten, 24 (3–4): 149–210, illus. 1959.

FAY, L. D., A. P. BOYCE, AND W. G. YOUATT. An epizootic in deer in Michigan. Trans. 21st North Amer. Wildlife Conference, pp. 173–184. 1956.

FIEDLER, W. Uber das Baculum der *Cheirogaleinae* (Primates). Zool. Anz., Leipzig, 163 (3–4): 57–63. August 1959.

FITZ, GRANCEL. Bear facts and fantasies. Sports Illustrated, 11 (14): 75–88, illus. 5 October 1959.

FLADE, J. E. Kreuzungen von Zwergpferd und Esel. Zool. Garten, 24 (3–4): 228–237. 1959.

FRECHKOP, S. L'évolution des equidés et le sabot du cheval. Mammalia, Paris, 23 (3): 318–328, pl. 12. September 1959.

FREEMAN, CLIFF, ED MANTHEI, AND ED SEALANDER. Black bear blitz. Wisconsin Conservation Bull., 24 (7): 12–14, illus. July 1959. (Bear damage in northwestern Wisconsin.)

FULLER, W. A. The horns and teeth as indicators of age in bison. Jour. Wildlife Management, 23 (3): 342–344, illus. July 1959.

GAZIN, C. LEWIS. Early Tertiary Apheliscus and Phenacodaptes as pantolestid insectivores. Smithsonian Misc. Coll., 139 (7): 1–7, illus. 12 August 1959.

GEE, E. P. Report on a survey of the rhinoceros area of Nepal, March and April 1959. Oryx, London, 5 (2): 59–85, 12 pls., 2 maps. August 1959.

GILMORE, RAYMOND M. Whales without flukes. Pacific Naturalist, 1 (9–10): 3–9. 6 August 1959.

GILMORE, RAYMOND M. On the mass strandings of sperm whales. Pacific Naturalist, 1 (9–10): 9–16. 6 August 1959.

GRIFFIN, DONALD R. Listening in the dark. The acoustical orientation of bats and men. Yale Univ. Press, New Haven, pp. xviii + 413. 1958.

GROMOVA, VÉRA. Première découverte d'un chat primitif au Paleogene d'Asie Centrale. Vertebrata Palasiatica, 3 (2): 59–72, illus. June 1959. (New: *Aelurogale mongoliensis.*)

GRZIMEK, G. Die Milch der Giraffengazellen, *Litocranius walleri* (Brooke). Zool. Garten, 24 (3–4): 283–284. 1959.

HABECK, JAMES R. A vegetational study of the central Wisconsin winter deer range. Jour. Wildlife Management, 23 (3): 273–278. July 1959.

HALAZON, GEORGE C., AND HELMUT K. BUECHNER. Postconception ovulation in elk. Trans. 21st North Amer. Wildlife Conference, pp. 545–554. 1956.

HAMILTON, W. J., JR., AND G. A. SCHAD. Parasitism of unweaned shrews by the cestode Hymenolepis falculata. Canadian Jour. Zool., 37 (3): 377. June 1959.

HANDLEY, CHARLES O., JR. A review of the genus Hoplomys (thick-spined rats), with description of a new form from Isla Escudo de Veraguas, Panamá. Smithsonian Misc. Coll., Washington, 139 (4): 1–10. 3 July 1959. (New: *H. gymnurus wetmorei.*)

HANDLEY, C. O., JR. A checklist of Virginia's mammals, birds, reptiles and amphibians. Mammals. Virginia Wildlife, 20 (9): 13. September 1959.

HANDLEY, CHARLES O., JR. A revision of American bats of the genera Euderma and Plecotus. Proc. U. S. Nat. Mus., 110 (3417): 95–246, illus. 3 September 1959.

HARRIS, VAN T. The nutria as a wild fur mammal in Louisiana. Trans. 21st North Amer. Wildlife Conference, pp. 474–486. 1956.

HART, J. S., AND L. IRVING. The energetics of harbor seals in air and in water with special consideration of seasonal changes. Canadian Jour. Zool., 37 (4): 447–457. August 1959.

HEINTZ, ANATOL. On the pollen analysis of the stomach contents of the Beresovka mammoth. Saertr. Blyttia, 16: 122–142, illus. 1958.

HEYMANN, HORST. Diagnostische Operation eines Tigers (*Panthera tigris*) unter "Thiogenal-Narkose". Zool. Garten, 24 (3–4): 248–252. 1959.

HILL, W. C. OSMAN. The anatomy of *Callimico goeldii* (Thomas). A primitive American primate. Trans. Amer. Philos. Soc., n.s., 49 (5): 1–116. September 1959.

HOFFMAN, ROGER A., AND CHARLES M. KIRKPATRICK. An analysis of techniques for determining male squirrel reproductive development. Trans. 21st North Amer. Wildlife Conference, pp. 346–355. 1956.

HOFFMEISTER, DONALD F. Distributional records of certain mammals from southern Arizona. Southwestern Naturalist, 4 (1): 14–19. June 1959.

HOFFMEISTER, DONALD F. New cricetid rodents from the Niobrara River Fauna, Nebraska. Jour. Paleontol., 33 (4): 696–699, illus. July 1959. (New: *Miochomys, M. niobrariensis*; *Peromyscus kelloggae.*)

HOFFMEISTER, DONALD F. The future status of the nutria, fur-bearing rodent, in Illinois. Trans. Illinois Acad. Sci., 51 (3–4): 48–50. 10 July 1959.

HOLMAN, J. ALAN. Birds and mammals from the Pleistocene of Williston, Florida. Bull. Florida State Mus., Biol. Sci., 5 (1): 1–25. 3 September 1959. (New: *Pitymys hibbardi.*)

HOOIJER, D. A. Trogonotherium cuvieri Fischer from the Neede Clay (Mindel-Riss Interglacial) of the Netherlands. Zool. Mededel. Rijksmus. Nat. Hist. Leiden, 36 (18): 275–280, pls. 13–14. 31 August 1959.

HOOIJER, D. A. Cornes de rhinocéros truquées. Mammalia, Paris, 23 (3): 316–317, pl. 11. September 1959.

HOUPT, T. R. Utilization of blood urea in ruminants. Amer. Jour. Physiol., 97 (1): 115–120. July 1959.

HOWE, A., AND P. A. JEWELL. Effects of water deprivation upon the neurosecretory material of the desert rat (*Meriones meriones*). Jour. Endocrinol., Cambridge, England, 18 (1): 118–123. January 1959.

HUDSON, PAUL, AND LUDVIG G. BROWMAN. Embryonic and fetal development of the mule deer. Jour. Wildlife Management, 23 (3): 295–304. July 1959.

HUGGEL, H.-J. La pression sanguine du système veineux autonome de l'aile de la rousette *Eidolon helvum* Kerr (*Macrochiroptera*). Rev. Suisse Zool., 66 (2): 315–321. August 1959.

HUSSON, A. M. Note on the Neotropical leaf-nosed bat *Sphaeronycteris toxophyllum* Peters. Arch. Néerlandaises Zool., vol. 13, suppl. 1, pp. 114–119. 1958.

INGLIS, JACK M. Relations of rodents to game populations. Dept. Wildlife Management, Texas Agric. Exper. Sta., College Station, pp. 23 + 341 (mimeogr.). 1 July 1959.

ISMAGILOV, M. I. Sex and age population composition and geographical variability of the suslik Citellus intermedius Br. Zool. Zhurnal, 38 (7): 1081–1088. July 1959. (In Russian, with English summary.)

JELGERSMA, H. C. Über mediale Anomalien bei Säugetieren im Vergleich mit der dysraphischen Konstitution beim Menschen. Zool. Anz., Leipzig, 163 (1–2): 26–34. July 1959.

JOHANSEN, KJELL, AND JOHN KROG. Diurnal body temperature variations and hibernation in the birch mouse *Sicista betulina*. Amer. Jour. Physiol., 196 (6): 1200–1204. June 1959.

JOHNSTON, J. P., AND E. GARDNER. Central connections of the optic nerves in mammals with pure-cone retinae. Anat. Record, Philadelphia, 134 (2): 205–216. June 1959.

JOLICOEUR, PIERRE. Multivariate geographical variation in the wolf *Canis lupus* L. Evolution, 13 (3): 283–299. September 1959.

JONES, J. KNOX, JR. A third locality record for the desert shrew, Notiosorex crawfordi, in New Mexico. Southwestern Naturalist, 4 (2): 111–112. 15 September 1959.

JONSGÅRD, ÅGE. New find of sword from swordfish (*Xiphias gladius*) in blue whale (*Balaenoptera musculus*). Norsk Hvalfangst-Tidende (Norwegian Whaling Gazette), 48 (7): 352–360. July 1959.

JONSGÅRD, ÅGE, AND E. JOHN LONG. Norway's small whales. Sea Frontiers, Bull. Internat. Oceanogr. Foundation, 5 (3): 168–174. August 1959.

JOUFFROY, F. K. L'indépendance du muscle ischio-condylien chez les Gibbons. Bull. Mus. Nat. Hist. Nat. Paris, ser. 2, 31: 330–333. June 1959.

KAHMANN, H. Notes sur le statut actuel de quelques mammifères menacés dans la région méditerranéenne. Mammalia, Paris, 23 (3): 329–331. September 1959.

KAY, R. N. B. Continuous and reflex secretion by the parotid gland in ruminants. Jour. Physiol., London, 144: 463–464. December 1958.

KAY, R. N. B. The effects of stimulation of the sympathetic nerve and of adrenaline on the flow of parotid saliva in sheep. Jour. Physiol., London, 144: 464–475. December 1958.

KENT, WILLIAM L. A lion comes to town. Colorado Outdoors, 8 (4): 28–29. August 1959. (Puma in Pueblo, Colorado.)

KENYON, KARL W. The sea otter. Annual Rept. Smithsonian Inst., 1958: 399–407, pls. 1–6. 1959.

KING, JUDITH E. A note on the specific name of the Kerguelen fur seal. Mammalia, Paris, 23 (3): 381. September 1959.

KITTS, DAVID B., AND ARTHUR J. MYERS. A Pliocene badger, *Pliotaxidea nevadensis* (Butterworth), from Harper County, Oklahoma. Oklahoma Geol. Notes, Oklahoma Geol. Surv., 19 (7): 143–145, illus. July 1959.

KLEIN, DAVID R. Track differentiation for censusing bear populations. Jour. Wildlife Management, 23 (3): 361–363. July 1959.

KLÖPPEL, GÜNTHER. Kaiserschnitt bei einem Puma. Zool. Garten, 24 (3–4): 220–222, illus. 1959.

KÖNIG, CLAUS Äussere Merkmale zur Bestimmung der lebenden Fledermäuse Europas. Säugetierk. Mitteil., 7 (3): 101–110, illus. 1 August 1959.

KRUGER, L. The thalamus of the dolphin (*Tursiops truncatus*) and comparison with other mammals. Jour. Comp. Neurol., Philadelphia, 111 (1): 133–194. February 1959.

KRUTZSCH, PHILIP H., AND S. EDWARD SULKIN. The anatomical distribution of the interscapular and parotid glands of the insectivorous bats Tadarida, Myotis and Pipistrellus. Anat. Record, Philadelphia, 134 (3): 397–432. July 1959.

KULZER, ERWIN. Fledermäuse aus Ostafrika. Über eine Sammlung von Chiropteren aus Kenia und Tanganyika mit ethologischen und ökologischen Beobachtungen. Zool. Jahrb., Syst., 87 (1–2): 13–42. 25 September 1959.

KUMMER, B. Biomechanik des Säugetierskelets. Handbuch der Zoologie, Berlin, Band 8, Teil 6, Beitrag 2 (Lieferung 24), pp. 1–80. September 1959.

KURTÉN, BJÖRN. On the bears of the Holsteinian interglacial. Acta Univ. Stockholm, Contrib. Geol., 2 (5): 73–102, illus. 24 April 1959.

LABISKY, RONALD F. Night-lighting: a technique for capturing birds and mammals. Biol. Notes Illinois Nat. Hist. Survey Div., 40: 1–11, illus. July 1959.

LABISKY, RONALD F., AND REXFORD D. LORD, JR. A flexible, plastic eartag for rabbits. Jour. Wildlife Management, 23 (3): 363–365, illus. July 1959.

LANDOWSKI, JAN. Erfahrungen in der Haltung von Schimpansen im Warschauer Zoo. Zool. Garten, 24 (3–4): 256–264, illus. 1959.

LANDRY, STUART O., JR. Lactation hair in the Asiatic squirrel and relationship of lactation hair to mammary hair. Science, 130 (3366): 37. 3 July 1959.

LANG, ERNST M. Einige seltenere Zuchterfolge im Basler Zoo. Zool. Garten, 24 (3–4): 282–283. 1959. (*Sarcophilus, Gorilla, Rhinoceros.*)

LANGE, ALFRED. Coyote's hunt. Blue Jay, Saskatchewan Nat. Hist. Soc., 17 (3): 123. September 1959. (Stalking and killing grouse.)

LANZA, BENEDETTO. Note sul cuscinetto buccale dei chirotteri. Boll. Zool., Unione Zool. Italiana, 23 (2): 263–273. October 1956.

LAWS, R. M. On the breeding season of Southern Hemisphere fin whales, *Balaenoptera physalus* (Linn.). Norsk Hvalfangst-Tidende (Norwegian Whaling Gazette), 48 (7): 329–351. July 1959.

LAWS, R. M. Accelerated growth in seals, with special reference to the Phocidae. Norsk Hvalfangst-Tidende (Norwegian Whaling Gazette), 48 (9): 425–452. September 1959.

LEHMANN, E. v. Eine Kleinsäugerausbeute aus Montenegro. Bonner Zool. Beitr., 10 (1–2): 1–20. 7 September 1959.

LESSERTISSEUR, J. Le diaphragme dans ses rapports avec l'évolution thoracique chez les Primates. Bull. Mus. Nat. Hist. Nat. Paris, ser. 2, 31: 322–329. June 1959.

LINZELL, J. L. Physiology of the mammary gland. Physiol. Reviews, 39 (3): 534–576. July 1959.

LORD, REXFORD D., JR. The lens as an indicator of age in cottontail rabbits. Jour. Wildlife Management, 23 (3): 358–360. July 1959.

LUETH, FRANCIS X. The lost fur market. Alabama Conservation, 31 (2): 24–25. August–September 1959.

MACDONALD, J. R. The middle Pliocene mammalian fauna from Smiths Valley, Nevada. Jour. Paleontol., 33 (5): 872–887. September 1959. (New: *Indarctos nevadensis.*)

MACKINTOSH, N. A. Biological problems in the regulation of whaling. Norsk Hvalfangst-Tidende (Norwegian Whaling Gazette), 48 (8): 395–404. August 1959.

MAO, HSIEH-CHÜIN, AND YIN YEN. Dental conditions of the Shang Dynasty skulls excavated from Anyang and Huü-Xian. Part 1. Dental caries and periodontoclasia. Vertebrata Palasiatica, 3(2): 79–80, 1 pl. June 1959.

MCKEEVER, STURGIS. Relative abundance of twelve southeastern mammals in six vegetative types. Amer. Midland Nat., 62 (1): 222–226. July 1959.

MCKEEVER, STURGIS. Effects of reproductive activity on the weight of adrenal glands in Microtus montanus. Anat. Rec., 135 (1): 1–5. September 1959.

MCLAUGHLIN, CHARLES A. Mammals of Los Angeles County, California. Los Angeles County Mus. Science Ser., No. 21 (Zool. No. 9), pp. 1–34, illus. 1959.

MERGNER, HANS. Untersuchungen am Organon vasculosum laminae terminalis (Crista supraoptica) im Gehirn einiger Nagetiere. Zool. Jahrb., Jena, 77 (3): 289–356. July 1959.

MEYER, G., M. VIAUD, AND J. RUF. Contribution a l'etude du sang des lemuriens malgaches. Mem. Inst. Sci., Madagascar, Ser. A., 12: 261–266. 1959.

MOHR, E. Die Füsse des Halsband-Pekaris, *Dicotyles torquatus*. Zool. Anz., Leipzig, 163 (3–4): 64–67. August 1959.

MOORE, JOSEPH CURTIS. Relationships among the living squirrels of the Sciurinae. Bull. Amer. Mus. Nat. Hist., 118 (4): 153–206. 27 July 1959.

Mori, Masahiko. On the arteries of the hand of Macacus cyclopis. Okajimas Folia Anat. Japonica, 32 (5): 241–274. February 1959.

Morrison, P., and F. A. Ryser. Body temperature in the white-footed mouse, *Peromyscus leucopus noveboracensis*. Physiol. Zoology, Chicago, 32 (2): 90–103. April 1959.

Myers, K., and W. E. Poole. A study of the biology of the wild rabbit, *Oryctolagus cuniculus* (L.), in confined populations. I. The effects of density on home range and the formation of breeding groups. C.S.I.R.O. Wildlife Research, Australia, 4 (1): 14–26. July 1959.

Mykytowycz, R. Effect of infection with myxomatosis virus on the endoparasites of rabbits. Nature, London, 183: 555–556. 21 February 1959.

Mykytowycz, R. Social behaviour of an experimental colony of wild rabbits, *Oryctolagus cuniculus* (L.). C.S.I.R.O. Wildlife Research, Australia, 4 (1): 1–13. July 1959.

N[ero], R. W. Water shrew at Hudson Bay. Blue Jay, Saskatchewan Nat. Hist. Soc., 17 (3): 125. September 1959.

New, John G. Additional uses of dyes for studying the movements of small mammals. Jour. Wildlife Management, 23 (3): 348–351. July 1959.

Newman, Duane E. Factors influencing the winter roadside count of cottontails. Jour. Wildlife Management, 23 (3): 290–294. July 1959.

Noback, C. R., and L. Goss. Brain of a gorilla. I. Surface anatomy and cranial nerve nuclei. Jour. Comp. Neurol., Philadelphia, 111 (2): 321–344. April 1959.

Noback, C. R. Brain of a gorilla. II. Brain stem nuclei. Jour. Comp. Neurol., Philadelphia, 111 (2): 345–385. April 1959.

Olsen, Stanley J. The archeologist's problem of getting non-artifactual materials interpreted. Curator, Amer. Mus. Nat. Hist., 2 (4): 335–338. 1959. (Principally mammalian bones.)

Olson, Everett C. The evolution of mammalian characters. Evolution, 13 (3): 344–353. September 1959.

Ormond, Clyde. Hunting our medium size game. Stackpole Co., Harrisburg, pp. 219, illus. 1958.

Paula Couto, C. de. Uma pequena preguica terricola de São Paulo. Brasileira Acad. Cien., 31 (1): 91–107, illus. 31 March 1959.

Petrides, George A. Big Game densities and range carrying capacities in East Africa. Trans. 21st North Amer. Wildlife Conference, pp. 525–537. 1956.

Petter, Francis. Evolution du dessin de la surface d'usure des molaires des gerbillidés. Mammalia, Paris, 23 (3): 304–315. September 1959.

Petter, F. Reproduction en captivité du zorille du Sahara *Poecilictis libyca*. Mammalia, Paris, 23 (3): 378–380, illus. September 1959.

Petter, Germaine. Evolution de la forme du marteau (*malleus*) chez le lion de la naissance a l'age adulte. Mammalia, Paris, 23 (3): 350–356, illus. September 1959.

Petzsch, Hans. Zur Frage animalischer Nahrungs-Anteile bei Wildkaninchen und Feldhasen. Säugertierk. Mitteil., 7 (3): 118. 1 August 1959.

Péwé, Troy L., Norman A. Rivard, and George A. Llano. Mummified seal carcasses in the McMurdo Sound region, Antarctica. Science, 130 (3377): 716. 18 September 1959.

Pfeffer, Pierre. Biologie et migrations du sanglier de Bornéo (*Sus barbatus* Muller 1869). Mammalia, Paris, 23 (3): 277–303. September 1959.

Philip, Cornelius B. Some epidemiological considerations in Rocky Mountain spotted fever. Public Health Repts., U.S. Publ. Health Serv., Washington, 74 (7): 595–600. July 1959.

Pilleri, G. Zur Morphologie und postembryonalen Entwicklung des Gehirns von

Dasyprocta aguti Lin. (Rodentia, Hystricomorpha). Rev. Suisse Zool., 66 (25): 545–553. August 1959.

POST, GEORGE. The use of curare and curare-like drugs on elk (wapiti). Jour. Wildlife Management, 23 (3): 365–366. July 1959.

PRAKASH, ISHWAR. Studies on the ecology of desert hedgehogs. Proc. Rajasthan Acad. Sci., 6: 24–30. July 1956.

PRAKASH, ISHWAR. Study of vertebrates in the Indian Desert. Turtox News, Chicago, 36 (11): 266. November 1958.

PRESNALL, CLIFFORD C. Changing trends in predator management. Trans. 21st North Amer. Wildlife Conference, pp. 185–190. 1956.

PRUITT, WILLIAM O., JR. Snow as a factor in the winter ecology of the barren ground caribou (*Rangifer arcticus*). Arctic, 12 (3): 159–179. September 1959.

QUICK, HORACE F. Analysis of marten exploitation as criteria of management. Trans. 21st North Amer. Wildlife Conference, pp. 355–364. 1956.

REINHART, ROY H. A review of the Sirenia and Desmostylia. Univ. California Publ. Geol. Sci., 36 (1): 1–146. 24 July 1959. (New: *Caribosiren, C. turneri, Halianassa vanderhoofi, Vanderhoofius, V. coalingensis, Paleoparadoxidae, Paleoparadoxia.*)

REINWALDT, EDWIN, AND EINO ERKINARO. Zur Taxonomie und Verbreitung des Baummarders, *Martes martes martes* (Linné 1758). Säugertierk. Mitteil., 7 (3): 97–100. 1 August 1959.

RINEY, T., J. S. WATSON, C. BASSETT, E. G. TURBOTT, AND W. E. HOWARD. Lake Monk Expedition. An ecological study in southern Fiordland. Bull. New Zealand Dept. Sci. & Indust. Research, 135: 1–75, Illus. 1959.

ROBINETTE, W. LESLIE, JAY S. GASHWILER, AND OWEN W. MORRIS. Food habits of the cougar in Utah and Nevada. Jour. Wildlife Management, 23 (3): 261–273. July 1959.

ROBINSON, PAUL F. Metabolism of the gerbil, Meriones unguiculatus. Science, 130 (3374): 502–503. 28 August 1959.

ROWLEY, IAN. Bait size for rabbits. C.S.I.R.O. Wildlife Research, Australia, 4 (1): 27–30. July 1959.

RUSCONI, CARLOS. Acerca del hombre fosil argentino y sus relaciones con las faunas extinguidas. Rev. Mus. Nat. Hist. Mendoza, 12: 13–113. 13 August 1959.

RUSCONI, CARLOS. Restos de mamíferos fosiles en Wilde Provincia de Buenos Aires. Rev. Mus. Nat. Hist. Mendoza, 12: 115–118. 13 August 1959.

SAINT-GIRONS, MARIE-CHARLOTTE. Les caractéristiques du rythme nycthéméral d'activité chez quelques petits mammifères. Mammalia, Paris, 23 (3): 245–276, illus. September 1959.

SERGEANT, DAVID E., AND DOUGLAS H. PIMLOTT. Age determination in moose from sectioned incisor teeth. Jour. Wildlife Management, 23 (3): 315–321. July 1959.

SIEGFRIED, PAUL. Das Mammut von Ahlen. Pal. Zeit., 33 (3): 172–184, illus. July 1959.

SIMPSON, GEORGE GAYLORD. Fossil mammals from the type area of the Puerco and Nacimiento strata, Paleocene of New Mexico. Amer. Mus. Novitates, 1957: 1–22. 5 August 1959.

SIMPSON, GEORGE GAYLORD. Mesozoic mammals and the polyphyletic origin of mammals. Evolution, 13 (3): 405–414. September 1959.

SKORKOWSKI, EDWARD. Das Problem der Subspecieszusammensetzung von Pferdepopulationen. Säugertierk. Mitteil., 7 (3): 113–118. 1 August 1959.

SMITH, D. E. The influence of X-irradiation upon dormancy in vertebrates. Jour. Exper. Zool., Philadelphia, 139 (1): 85–94. October 1958.

SOPER, EILEEN A. When badgers wake. Routledge & Kegan Paul, Ltd., London, pp. 220, illus. 1955.

SPILLMAN, FRANZ. Die Sirenen aus dem Oligozän des linzer Beckens (Oberösterreich),

mit Ausführungen über "Osteosklerose" und "Pachyostose". Österreich. Akad. Wiss., Math.-Nat. Klasse, 110 (3): 1–68, illus. 1959. (New. *Halitherium abeli.*)

STARCK, D. Ontogenie und Entwicklungsphysiologie der Säugetiere. Handbuch der Zoologie, Berlin, Band 8, Teil 9, Beitrag 7 (Lieferung 22), pp. 1–276. August 1959.

STEIN, GEORG H. W. Ökotypen beim Maulwurf, Talpa europaea L. (Mammalia). Mittel. Zool. Mus. Berlin, 35 (1): 3–43. 25 July 1959.

STENLUND, MILT. Our white-tailed deer problem. Animal Kingdom, New York Zool. Soc., 62 (4): 106–110, illus. August 1959.

STRAUSS, F. Der Eileiter des Goldhamsters. Verhandl. Schweiz. Naturf. Gesell, 1958: 140–141. 1958.

STRUMWASSER, F. Factors in the pattern, timing and predictability of hibernation in the squirrel *Citellus beecheyi*. Amer. Jour. Physiol., 196 (1): 8–14. January 1959.

STRUMWASSER, F. Thermoregulatory, brain and behavioral mechanisms during entrance into hibernation in the squirrel *Citellus beecheyi*. Amer. Jour. Physiol., 196 (1): 15–22. January 1959.

STRUMWASSER, F. Regulatory mechanisms, brain activity and behavior during deep hibernation in the squirrel *Citellus beecheyi*. Amer. Jour. Physiol., 196 (1): 23–30. January 1959.

SWANK, WENDELL G. Protein and phosphorus content of browse plants as an influence on southwestern deer herd levels. Trans. 21st North Amer. Wildlife Conference, pp. 141–158. 1956.

THENIUS, ERICH. Über einen Kleinbären aus dem Pleistozän von Slowenien nebst Bemerkungen zur Phylogenese der Plio-Pleistozänen Kleinbären. Razprave Slov. Akad. Znan. in Umetn., 4: 633–646, illus. 1958.

THENIUS, ERICH. *Indarctos arctoides* (Carnivora, Mammalia) aus dem Pliozän Österreichs nebst einer Revision der Gattung. Neues Jahrb. Geol. Paläont., Abh., 108 (3): 270–295, illus. 1959.

THENIUS, ERICH. Ursidenphylogenese und Biostratigraphie. Zeitschr. Säugetierk. 24: 78–84, illus. 1959.

THOMPSON, DONALD R. Field techniques for sexing and aging game animals. Special Wildlife Rept. Wisconsin Conserv. Dept., 1: 1–44, illus. 1958.

TOOHEY, LOREN. The species of *Nimravus* (Carnivora, Felidae). Bull. Amer. Mus. Nat. Hist., 118 (2): 71–112, illus. 20 July 1959.

TORRE, LUIS DE LA. The status of the bat *Myotis velifer cobanensis* Goodwin. Proc. Biol. Soc. Washington, 71: 167–170. 31 December 1958.

UHLIG, HANS G. Effect of legal restrictions and hunting on gray squirrel populations in West Virginia. Trans. 21st North Amer. Wildlife Conference, pp. 330–338. 1956.

ULLRICH, WOLFGANG. Bezoarkugel bei einem Schimpansen. Zool. Garten, 24 (3–4): 281–282, illus. 1959.

VAN DEN BERGH, WALTER. Encore une fois: les rhinocéros blancs. Zool. Garten, 24 (3–4): 285. 1959.

VAUGHAN, TERRY A. Functional morphology of three bats: Eumops, Myotis, Macrotus. Univ. Kansas Publ., Mus. Nat. Hist., 12 (1): 1–153, illus. 8 July 1959.

VOLF, J. Note complémentaire sur le statut actuel des chevaux de Przewalski en 1958. Mammalia, Paris, 23 (3): 380–381. September 1959.

VOS, A. DE. Summer studies of moose in Ontario. Trans. 21st North Amer. Wildlife Conference, pp. 510–525. 1956.

WATSON, GORDON W., AND ROBERT F. SCOTT. Aerial censusing of the Nelchina caribou herd. Trans. 21st North Amer. Wildlife Conference, pp. 499–510. 1956.

WATSON, J. S. Reproduction of the wild rabbit, *Oryctolagus cuniculus* (L.) in Hawke's

Bay, New Zealand. New Zealand Jour. Sci. & Technol., sec. B, 38 (5): 451–482. March 1957.

WATSON, J. S. Control requires study of rabbit's life history and habits. New Zealand Young Farmer, 11 (2): 1–2 (of reprint). February 1959.

WATZKA, MAX. Superfecundatio, Superfetatio, multiple Ovulation, Zwillinge, Mehrlinge bei Säugetieren. Handbuch der Zoologie, Berlin, Band 8, Teil 9, Beitrag 10 (Lieferung 23), pp. 1–24. September 1959.

WETTSTEIN, OTTO V. Eine übersehene Unterart von *Sus scrofa* L. Säugertierk. Mitteil., 7 (3): 118. 1 August 1959. (*S. leucomystax sibiricus* Staffe, 1922.)

WHITE, THEODORE E. The endocrine glands and evolution, No. 3: Os cementum, hypsodonty, and diet. Contrib. Mus. Paleontol. Univ. Michigan, 13 (9): 211–265. 31 July 1959.

WHITLOCK, S. C., AND LEE EBERHARDT. Large-scale dead deer surveys: methods, results and management implications. Trans. 21st North Amer. Wildlife Conference, pp. 555–566. 1956.

WODZICKI, K., AND R. H. TAYLOR. An experiment in rabbit control. Kourarau poison trials. New Zealand Jour. Sci. & Technol., sec. B, 38 (5): 389–399. March 1957.

WOO, JU-KANG. Human fossils found in Liukiang, Kwangsi, China. Vertebrata Palasiatica, 3 (3): 115–118, illus. September 1959.

WOO, JU-KANG, XIN-ZHI WU, AND CUN-YI WANG. New reconstruction of physiognomy of *Sinanthropus* woman. Vertebrata Palasiatica, 3 (3): 165–166, illus. September 1959.

WOOD, A. E. Are there rodent suborders? Syst. Zool., 7 (4): 169–173. December 1958.

WOOD, ALBERT E. Eocene radiation and phylogeny of the rodents. Evolution, 13 (3): 354–361. September 1959.

WOTTON, R. M., AND M. A. HAIRSTONE. Further studies on the direct and visible ingestion of fat by the intestinal epithelium in the cat. Anat. Record, 134 (2): 143–152. June 1959.

YAMANE, JINSHIN, AND TAKAO KASHIWABARA. The role of testicular hyaluronidase in spermatogenesis of mammals. Jour. Faculty Fisheries and Animal Husbandry, Hiroshima Univ., 1 (3): 321–336, pls. 1–3. December 1957.

YEATES, N. T. M. Foetal dwarfism in sheep—an effect of high atmospheric temperature during gestation. Jour. Agric. Sci., 51 (1): 84–89, pl. 4. 1958.

YOUATT, W. G., L. D. FAY, G. L. WHITEHEAD, AND J. P. NEWMAN. Brucellosis and leptospirosis in white-tailed deer in Michigan. Jour. Wildlife Management, 23 (3): 345–348. July 1959.

ZIMMERMANN, K. Über eine Kreuzung von Unterarten der Feldmaus *Microtus arvalis*. Zool. Jahrbücher, Jena, Abt. Syst., 87 (1–2): 1–12. 25 September 1959.

ZIMNY, MARILYN L., AND R. GREGORY. High-energy phosphates during long-term hibernation. Science, 129 (3359): 1363–1364. 15 May 1959.

ZUH-MING, DIEN. The Formosan rock-monkey. Quart. Jour. Taiwan Mus., 11 (3–4): 345–348. December 1958.

COMMENTS AND NEWS

MAMMAL SYMPOSIUM

The Laboratory of Vertebrate Investigation of the Czechoslovak Academy of Sciences announces plans for a "Symposium on the Methodics of Mammalian Investigation" to be held from 1–10 September 1960. Foreign scientists are invited to attend and to present papers, but titles should have been submitted before now. For details, address Prof. dr. J. Kratochvíl, Corresponding Member of the Academy, Brno, Plotní 25a, Czechoslovakia.

TRUE AND FALSE DATES OF PUBLICATION

Because of the rule of priority in nomenclature, it is always a good policy and often a vital necessity for a taxonomist to know the exact dates on which publications that he cites were issued. To non-taxonomists, who are the majority among biologists, precise dating of publications has no special significance. Many technical journals that carry taxonomic papers print an exact date of publication on each issue. This practice is so helpful to taxonomists that its omission may cause adverse comment. In the last issue of this Journal (p. 144), E. Raymond Hall protests the absence of such a date on one of the *Proceedings* of the U. S. National Museum. Because he and some others profess to see no reason why the date should be omitted, and because there is actually a very good reason, discussion of concurrent dating versus subsequent dating of technical papers is called for.

The paper in question was published on 3 September 1959. This is a true date, and taxonomists can rely on it. It is a fact of history derived from the records of the Editorial and Publications Division of the Smithsonian Institution. There is no foreseeable reason why it will ever be doubted or corrected. It will be published in the table of contents of vol. 110 of the *Proceedings* and also in the 1960 *Annual Report* of the National Museum; taxonomists may transfer the date with confidence from either of those sources to their personal or institutional copies of the article. The obvious virtue of this method of dating publications is its absolute accuracy, which ought to be the primary consideration of taxonomists.

But what of the accuracy of dates that are printed on publications when they are issued? Having scanned most of the literature on recent mammals for several years, I am quite skeptical about many such dates. In the Division of Mammals of the National Museum, our staff attempts to determine the date of publication of each new technical name that is proposed for recent mammals and each title that is cited in the Recent Literature section of this Journal. Some of the concurrently printed dates are apparently valid, some are doubtful, and some are obviously wrong. The important fact is that all are target dates which, because of the mechanics of printing, had to be set up days or weeks in advance of publication. Hitting such targets requires close cooperation among editors, printers and publishers, and the success achieved depends to some extent on luck as well as on skill and determination. The markmanship is generally good among the tightly controlled series that specialize in separate taxonomic papers, mediocre among the large quarterly journals, and poor among the reports of local natural history societies. Dr. Hall rates as a sharpshooter on the record of the publications that he directly controls.

The concurrent dating system is such a delicate mechanism that in the practical world of publishing it is bound to break down at times. Transportation tie-ups and wartime restrictions have disrupted carefully planned publication schedules. A strike of printers in Britain last year delayed most biological journals for several months. Dates printed on some issues of the *Journal of Mammalogy* and *North American Fauna* have had to be corrected, though some systematists are not aware of the fact. Some publications do not try to adhere strictly to printed dates; the weekly magazine *Science*, which is published in Washington, usually arrives at the Smithsonian Library by mail on the printed date, often on the day before. Some apparently believe that an "official" date will be accepted even if the mailing is a few days off, but in judging a critical case of priority no taxonomist will accept a date that he knows is false. Delayed papers sometimes bear corrected dates that have been overprinted, rubber-stamped, or manually entered. Even these are subject to the same doubt as any concurrent dates, and one never knows if the corrections were made on all copies, for instance on reprints sold directly to authors by printers.

With all these drawbacks, however, the concurrent dating system is of such practical convenience to taxonomists that it is not likely to be altogether abandoned, nor do I think it should be by those small specialized publications that are rigidly controlled by taxonomists. Those that have a bad record of error, or that because of unwieldly publishing arrangements run a material risk of misdating, should be content to report the date after it has been established. A simple and highly satisfactory system has been used for many years by the

Proceedings of the Zoological Society of London; each number of that journal, itself only generally dated, reports the precise date on which the previous number was issued.—DAVID H. JOHNSON.

In recent years, issues of the *Journal of Mammalogy* have been mailed on the dates printed on the lead page. Our printer has assured us (13 December 1958) that "we not only always mail on the date published but have Post Office receipts signed by responsible Post Office employees attesting to the fact. . . . In all cases where we are mailing scientific dated material . . . we get such receipts and keep these dates inviolate."—ED.

I.U.C.N. GENERAL ASSEMBLY

The 7th General Assembly and the 8th Technical Meeting of the International Union for Conservation of Nature and Natural Resources will be held at Warsaw, Poland, 15–24 June 1960, and excursions will be run from Cracow, 24–29 June. The technical program will include consideration of the management of wild grazing animals and its relation to land use, and of the ecological effects of biological and chemical control of undesirable plants and animals. There will be opportunity to see the wisent and the tarpan at the National Park at Bialowieza, the birthplace of Chopin at Zelazowa Wola, and the boundary National Parks of Poland and Czechoslovakia in the mountains of Tatra and Pieniny. Further details are available from the Secretariat of the Union, 31, rue Vautier, Brussels 4, Belgium.

EXHIBITION OF NATURAL HISTORY PHOTOGRAPHS

Word has been received of the 1960 International Exhibition of Photography to be held at the Laing Municipal Art Gallery, Newcastle upon Tyne, England, from 15 October to 5 November. A special Nature Section will feature pictures in the fields of botany, entomology, ornithology and general zoology. Closing dates for entries are 14 September (colored or black and white prints) and 28 September (colored transparencies). Entry forms and other details may be requested from the Hon. Exhibition Sec., W. Warburton Pope, 9 Kimberley Gardens, Newcastle upon Tyne 2, England.

SPECIAL SALE OF "RECENT LITERATURE"

To dispose of its stock of reprints of the "Recent Literature" bibliographic section of the *Journal of Mammalogy*, the Society offers sets to members at bargain rates. Issuance of reprints stopped with vol. 40. More or less complete sets issued during the period 1928–1959 are available and will be sold, beginning with the most complete, in the order that requests are received. The fullest sets include about 120 sections (a total of about 30,000 titles).

Sets will be priced individually at the rate of five cents per section, plus actual shipping cost. Orders should be addressed to Dr. David H. Johnson, Division of Mammals, U. S. National Museum, Washington 25, D. C. Do not send payment with your order. Members who receive sets will be billed later by the Secretary-Treasurer.

DEATHS REPORTED

Philip M. Blossom, Life Member, 21 February 1960

Harold H. Haecker, 20 February 1959

TENTH PACIFIC SCIENCE CONGRESS

The Pacific Science Association will hold its Tenth Congress, under the joint auspices of the National Academy of Sciences and the Bernice P. Bishop Museum and in cooperation with the University of Hawaii, at Honolulu from 21 August to 6 September 1961. It is hoped that this early announcement will stimulate widespread interest. A Circular of Information and other particulars may be requested from the Secretary-General, Tenth Pacific Science Congress, Bishop Museum, Honolulu 17, Hawaii, U.S.A.

PERSONAL NOTICES

This space is available to members of the Society for brief notices of interest to mammalogists. Copy should be sent to the Editor by the 10th of the month preceding publication. Rates for single insertion are 25 cents per line or portion thereof. Notices will be continued in each issue unless cancellation is received a month before publication or unless specified in original order. Bills will be rendered by the Secretary-Treasurer following publication.

FOR SALE—*Japanese "Mist" Bat Nets.* Send for price list. W. B. Davis, 254 F.E., College Station, Texas.

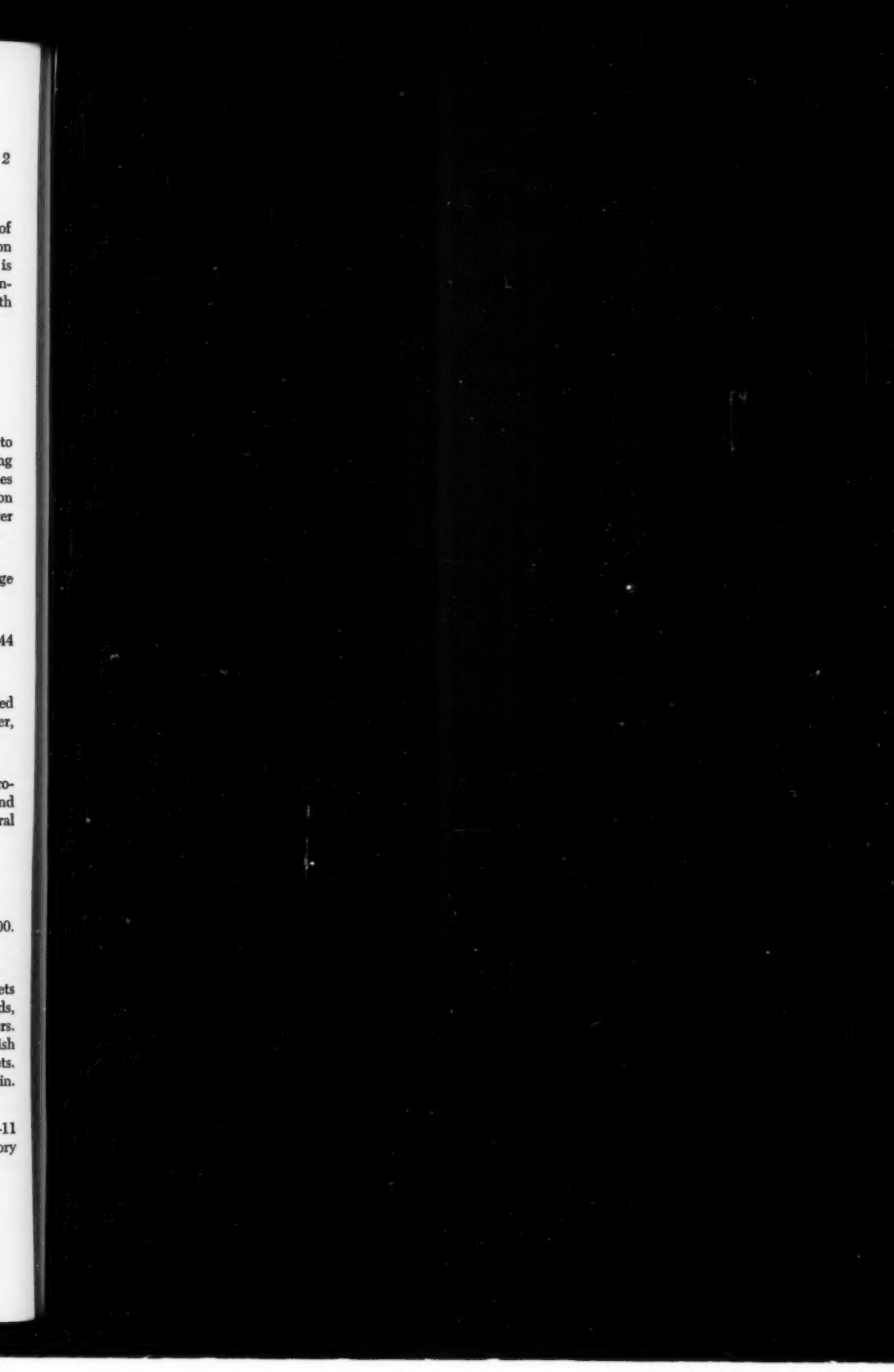
FOR SALE—Live desert rodents. Send for information and price list. Keith E. Justice, 44 W. Rillito St., Tucson, Arizona.

KEY TO THE SKULLS OF NORTH AMERICAN MAMMALS, by Bryan P. Glass, has been reprinted and may be ordered from the Research Foundation, Oklahoma State University, Stillwater, Oklahoma. Price $2.00 as in the past.

URGENTLY NEEDED—*Serum of foreign pinnipeds* for a comparative study involving electrophoretic and immunologic work on pinnipeds of the world. Directions for preservation and shipping sent on request; we assume shipping costs. Murray L. Johnson, Museum of Natural History, University of Puget Sound, Tacoma 6, Washington, U. S. A.

FOR *Sherman Live Traps* write H. B. Sherman, P.O. Box 683, De Land, Florida.

FOR SALE—Bailey's *The Mammals of Virginia,* 432 pp., 99 illus., 1946. Originally $5.00. Few copies left, $2.50 each. John W. Bailey, 27 Willway Rd., Richmond 26, Va.

ALL-PETS MAGAZINE is written for hobbyists, breeders, fanciers and people engaged in pets for profit; covers all unusual livestock kept as pets, plus aquaria, cage and aviary birds, cats and dogs; subscription $3.50 per year. Manuscripts solicited from ASM members. Established 25 years, circulation world-wide, 80 pages and up monthly. We also publish books on pet livestock; some 80 titles now. National distributors of some 350 books on pets. Write for free book circular to Frank Dittrich, 139 Darling Place, Fond du Lac, Wisconsin.

FOR SALE—*Transactions San Diego Society of Natural History,* complete set, Vols. 1–11 with Vol. 12 in progress, newly bound in blue buckram, $125. L. M. Huey, Natural History Museum, Balboa Park, San Diego 1, Calif.